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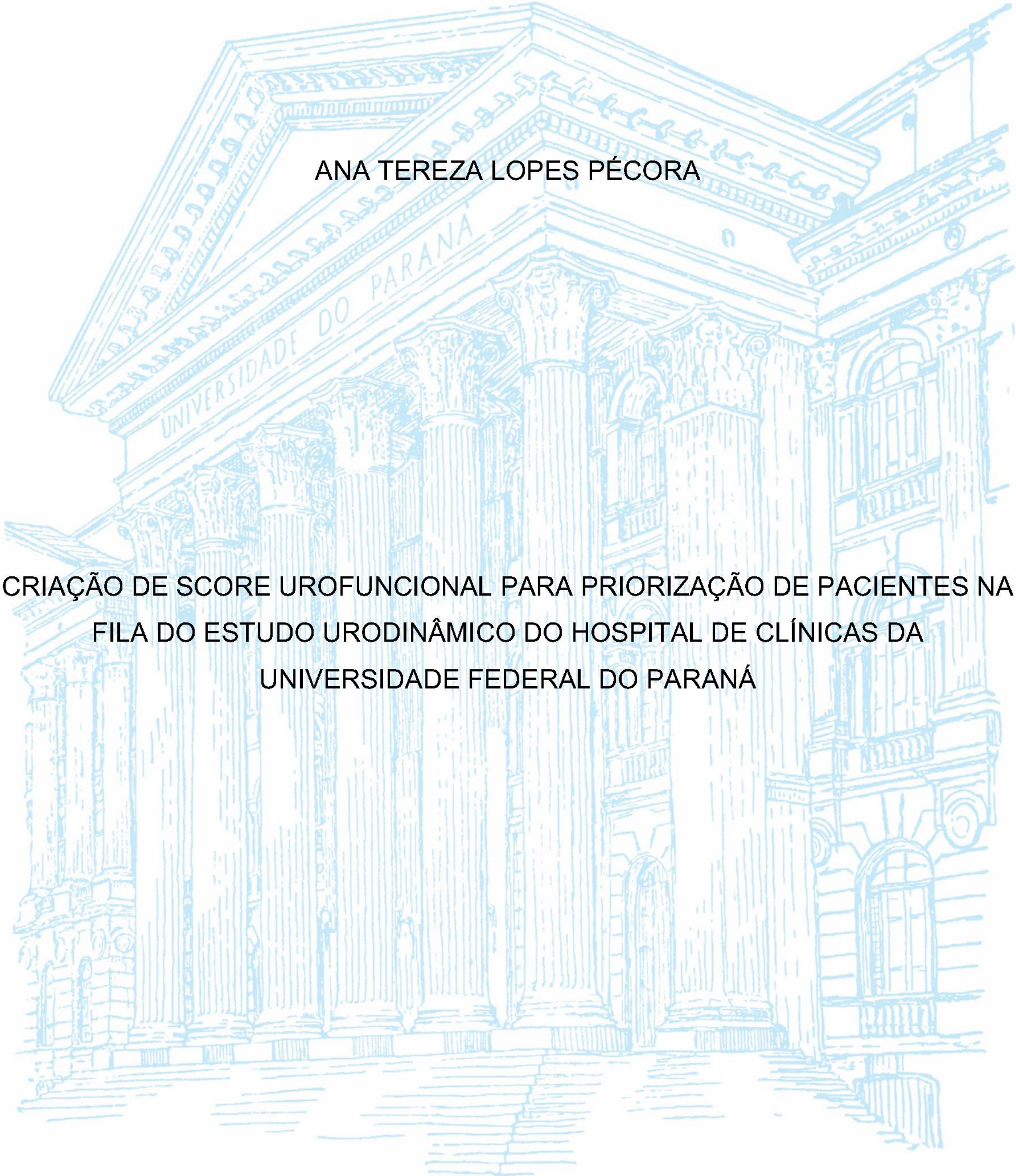

ANA TEREZA LOPES PÉCORA

CRIAÇÃO DE SCORE UROFUNCIONAL PARA PRIORIZAÇÃO DE PACIENTES NA FILA DO ESTUDO URODINÂMICO DO HOSPITAL DE CLÍNICAS DA UNIVERSIDADE FEDERAL DO PARANÁ

CURITIBA

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Tese apresentada ao curso de Pós-graduação em Clínica Cirúrgica, Setor de Ciências da Saúde, Universidade Federal do Paraná, como requisito parcial à obtenção do título de Doutor em Clínica Cirúrgica.

Orientador: Prof. Dr. Rogério de Fraga
Coorientadora: Prof. Dra. Marie-Ève Lamontagne

CURITIBA
2022

P369

Pécora, Ana Tereza Lopes
Criação de score urofuncional para priorização de pacientes

na fila do estudo urodinâmico do Hospital de Clínicas da Universidade Federal do Paraná [recurso eletrônico] / Ana Tereza Lopes Pécora – Curitiba, 2022.

Tese (doutorado) – Programa de Pós-Graduação em
Clinica Cirúrgica. Setor de Ciências da Saúde. Universidade Federal do Paraná.
Orientador: Prof. Dr. Rogério de Fraga
Coorientadora: Profa. Dra. Marie-Ève Lamontagne

1. Urodinâmica. 2. Prioridades em saúde. 3. Pacientes.
4. Pesquisa. 5. Simulação. 6. Lógica fuzzy. I. Fraga, Rogério de. II. Lamontagne, Marie-Éve. III. Programa de Pós-Graduação em Clínica Cirúrgica. Setor de Ciências da Saúde. Universidade Federal do Paraná. IV. Título.

NLM: WJ 102

FICHA CATALOGRÁFICA ELABORADA PELO SISTEMA DE BIBLIOTECAS/UFPR
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UNIVERSIDADE FEDERAL DO PARANÁ
PRÓ-REITORIA DE PESQUISA E PÓS-GRADUAÇÃO
PROGRAMA DE PÓS-GRADUAÇÃO MEDICINA (CLÍNICA CIRÚRGICA) - 40001016018P0

TERMO DE APROVAÇÃO

Os membros da Banca Examinadora designada pelo Colegiado do Programa de Pós-Graduação MEDICINA (CLÍNICA CIRÚRGICA) da Universidade Federal do Paraná foram convocados para realizar a arguição da tese de Doutorado de **ANA TEREZA LOPES PECORA** intitulada: **CRIAÇÃO DE SCORE UROFUNCIONAL PARA PRIORIZAÇÃO DE PACIENTES NA FILA DO ESTUDO URODINÂMICO DO HOSPITAL DE CLÍNICAS DA UNIVERSIDADE FEDERAL DO PARANÁ**, sob orientação do Prof. Dr. ROGERIO DE FRAGA, que após terem inquirido a aluna e realizada a avaliação do trabalho, são de parecer pela sua aprovação no rito de defesa.

A outorga do título de doutora está sujeita à homologação pelo colegiado, ao atendimento de todas as indicações e correções solicitadas pela banca e ao pleno atendimento das demandas regimentais do Programa de Pós-Graduação.

CURITIBA, 15 de Março de 2022.

ROGERIO DE FRAGA
Presidente da Banca Examinadora

LUCIANA SCHLEDER GONÇALVES
Avaliador Externo (40001016)

RITA DE CÁSSIA DOMANSKY
Avaliador Externo (UNIVERSIDADE ESTADUAL DE LONDRINA)

CLEVERSON RENAN DA CUNHA
Avaliador Externo (40001016)

AGRADECIMENTOS

Em primeiro lugar agradeço a Deus por ter me capacitado e me sustentado até o final desta caminhada. Josué 1:9 “não te mandei eu? Seja forte e corajoso, não temas nem te desanime, pois o Senhor teu Deus estarei contigo onde quer que andares”.

Ao meu marido Eduardo, meu companheiro e amigo de todos os momentos, meu maior incentivador.

Às minhas princesas Giovanna e Marianna, que estiveram ao meu lado durante esta caminhada. Amo vocês mais que o MUNDO!

Aos meus pais Haroldo e Maria Lúcia por toda dedicação e incentivo que sempre me deram.

Ao meu orientador Rogério de Fraga pela oportunidade de ter feito parte deste trabalho que como ele mesmo diz tornou-se algo gigante.

Ao meu amigo, Lydio Barbier Neto, residente em urologia, por ter sempre se prontificado a me ajudar nesta pesquisa.

Merci à mon ami Angel Ruiz *pour son aide et sa collaboration à ce travail* (Ao meu amigo Angel Ruiz por toda colaboração e ajuda neste trabalho).

À ma co-directrice Marie Ève Lamontagne pour m'avoir offert le stage, qui a été une expérience d'apprentissage formidable (À minha coorientadora Marie Ève Lamontagne por me proporcionar o estágio, o qual foi de grande aprendizado).

À todos os médicos que prontamente aceitaram responder o questionário.

À todos os meus amigos que oraram por mim durante esta caminhada.

“Não te mandei eu? Seja Forte e Corajoso!
Não te apavores nem te desanimes, pois o
Senhor o seu Deus, estará contigo onde quer
que você andar.”

Josué 1:9

RESUMO

Esta tese trata-se do desenvolvimento de scores de prioridade para o estudo urodinâmico. O estudo iniciou com a formação de um grupo multidisciplinar, no qual participaram médicos, enfermeiros, estudantes de medicina, administradores, engenheiro e matemático computacional. para determinação dos critérios de prioridade do exame, os quais foram baseados nos *guidelines* médicos, esta árvore de critérios foi chamada de Classificação Urofuncional. A estratégia de gestão do projeto, foi baseada nos passos da escola de administração da Universidade de Harvard. Como método de análise foi escolhido o Fuzzy AHP, este método permite que situações que envolvem critérios subjetivos possam ser quantificadas, determinando scores para cada critério. Após a aplicação do questionário Fuzzy AHP scores de prioridades foram atribuídos a cada um dos critérios da classificação urofuncional. Verificação e validação dos scores foram realizados com os experts no estudo urodinâmico, através da simulação, com pacientes reais, os quais já haviam sido referenciados para realização do estudo. Esta ferramenta demonstrou-se efetiva sendo aprovada e referenciada pelos experts para implementação na fila do estudo urodinâmico do Complexo Hospital de Clínicas da Universidade Federal do Paraná.

Palavras-chave: Priorização. Fuzzy AHP. Estudo Urodinâmico. Simulação. Ferramentas de priorização de pacientes.

ABSTRACT

This thesis is about the development of priority scores for the urodynamic study. The study started with the formation of a multidisciplinary team, in which physicians, nurses, medical students, administrators, an engineer and a computational mathematician participated. To determine the priority criteria for the exame, we were based on medical *guidelines*. This criteria tree was called Urofunctional Classification. The project management strategy, was based on the steps of the Harvard University business school. As an analysis method the Fuzzy AHP was chosen, this method allows situations whith involving subjective criteria to be quantified, determining scores for each criterion. After applying the Fuzzy AHP questionnaire, priority scores were assigned to each criteria of the urofunctional classification. Verification and validation of the scores were performed with experts in the urodynamic study, through simulation, with real patients, who had already been referred for the study. This tool has proven effective and was approved and referenced by experts for implementation in the urodynamic study queue at the Federal University of Paraná's Hospital de Clínicas Complex.

Keywords: Prioritization. Fuzzy AHP. Urodynamic study. Simulation. Patient prioritization tools.

PREFÁCIO

Esta tese faz parte de um projeto de desenvolvimento tecnológico mais amplo, multicêntrico, multidisciplinar, o qual teve como objetivo a criação de uma plataforma de priorização de pacientes.

Dentro desta equipe multidisciplinar estão envolvidos profissionais da área clínica como médicos, enfermeiros, osteoterapeutas, fisioterapeutas, terapeutas ocupacionais. A área matemática computacional contou com profissionais matemáticos, engenheiros, profissionais da tecnologia da informação dentre outros.

Além da priorização de pacientes na fila do estudo urodinâmico, a qual é a mais adiantada dentro da plataforma, esta conta também com outros problemas de saúde como: priorização de próteses para pacientes amputados, medidas de risco para COVID-19, vestimenta compressiva para grandes queimados e estudo da mobilidade para pessoas com deficiência física.

Para realização do pesquisa de priorização de pacientes na fila do estudo urodinâmico atendidos no Complexo Hospital de Clínicas da Universidade Federal do Paraná, foi firmado um convênio com esta universidade e a Universitè Laval, Quebec Canadá.

Como pesquisadora clínica desta equipe, coube a mim a participação na definição dos z de priorização, realização das entrevistas com os experts que realizam o estudo urodinâmico, entrevistas e coleta de dados com os pacientes e participação de discussões entre os experts clínicos e matemáticos.

Durante o desenvolvimento da pesquisa realizei um estágio de um ano na universidade Laval, o qual envolveu a Faculdade de Administração representada pelo Centre Interuniversitaire de Recherche Sur le Réseau de L'enterprise, Logistique et Transport (CIRRELT) e a Faculdade de medicina, representada pelo Centro de pesquisa Centre Interdisciplinaire de Recherche en Rèadaptation et Intégration Sociale (CIRRIS).

Como resultado deste estágio fui convidada a participar de dois artigos de revisão sistemática como coautora, sendo eles: A systematic review of patient prioritization tools in non-emergency healthcare services publicado na revista Systamatic Reviews (2020) https://doi.org/10.1186/s13643-020-01482-8.

O outro artigo Strategies to reduce waiting times in outpatient rehabilitation services for adults with physical disabilities: A systematic literature review aceito no Journal of Health Service Research & Policy (2021), os quais agregaram conhecimento para elaboração deste estudo.

Esta tese foi elaborada em dois artigos os quais serão descritos abaixo. O primeiro artigo: Project Planning for improvement in a healthcare environment: Developing a prioritization approch to managing patients' access to the urodynamics exam., publicado na revista Journal of Modern Project Manegement em 2021.

O estudo piloto deste artigo foi aceito como: Apresentação Oral e trabalho completo na 4e Conférence Internationale en Géstion de projet de UQTR, 2019, Trois Riviéres. Québec, Canadá, como Poster: Estudo de Caracterização Uro-Funcional de Uma Lista de Espera para Indicação do Estudo Urodinâmico no: IV Congreso Internacional da Asociación Latinoamericana de Piso Pélvico, 2019, Santiago Chile e apresentação Oral: Projeto De Priorização Da Fila De Urodinâmica no IV Congreso Internacional da Asociación Latinoamericana de Piso Pélvico, 2019, Santiago Chile.

O segundo artigo: Evaluation and Validation of a new Patiet Parioritization Tool. Este artigo está finalizado, aguardando decisão para qual revista será enviado.

O desenvolvimento deste estudo trouxe para a realidade da saúde grande desenvolvimento tecnológico com características de inovação e empreendedorismo, bem como parcerias entre universidades brasileiras e internacionais, agregando conhecimento e trazendo à tona a capacidade da ciência brasileira.

LISTA DE FIGURAS

LISTA DE ABREVIATURAS OU SIGLAS

AHP	Analitic Hierarchy Process
AUA	American Urological Association
BH	Bexiga Hiperativa
BPH	Benign Prostatic Hyperplasia
CDSS	Clinical Decision Support System
CHC	Complexo Hospital de Clínicas
CIRRELT	Centre Interuniversitaire de Recherche Sur le Réseau de L'enterprise, Logistique et Transport
CIRRIS	Centre Interdisciplinaire de Recherche en Rèadaptation et Intégration Sociale
FIFO	First In, First Out
FUZZY AHP	Analytic Hierarchic Process
HC-UFPR	Hospital das Clínicas Universidade Federal do Paraná
IPSS	Escore funcional de Sintomas Prostáticos
IU	Incontinência Urinária
IUE	Incontinência urinária de esforço
IUM	Incontinência Urinária Mista – Mixed Urinary Incontinence
LUTS	Low Urinary Tract Symptoms
NB	Bexiga Neurogênica – Neurogenic Bladder
PPT	Ferramentas de Priorização de Pacientes – Patient Priorityzation Tools
SUFU	Society of Urodynamics Female Pelvic Medicine and Urogenital Reconstruction
SUS	Sistema Único de Saúde

SUMÁRIO

1 INTRODUÇÃO

O Serviço de urodinâmica do Complexo Hospital de Clínicas (CHC) é um serviço com um volume de exames extremamente grande, pois além de atender os pacientes vindos do ambulatório da urologia, recebe também pacientes de outras especialidades como ginecologia e coloproctologia. Desta forma, a fila cresceu ao ponto de ter um tempo médio de espera de 3 anos, com aproximadamente 3.000 pacientes na fila.

Dentro do CHC temos um serviço de Ouvidoria Hospitalar onde os pacientes podem registrar suas reclamações e, também, elogios. Neste contexto a urodinâmica é o serviço da unidade de urologia que mais recebe reclamações, isto ocorre pois o número de exames solicitado é maior do que a possibilidade do hospital em realizá-lo.

Devido a todos estes problemas a direção do hospital apoiou a ideia da criação de um grupo multidisciplinar para mapear e melhorar o fluxo de atendimento dos pacientes que necessitam a realização do estudo urodinâmico.

O grupo contou com a participação de médicos, enfermeiros, acadêmicos de medicina, residentes, administradores, estatísticos, tecnólogos da informação e administradores.

A partir destas reuniões levantamos várias hipóteses definindo a pergunta de pesquisa: Como desenvolver um Score Urofuncional para classificação de risco dos pacientes que tem necessidade de realização de Estudo Urodinâmico?

Para a melhor resolução deste problema, foram integrados ao grupo um matemático computacional e um engenheiro, estes dois profissionais com muita experiência em priorização na área da saúde e análise de métodos computacionais.

Durante as reuniões foram elaborados critérios e subcritérios para priorização do estudo urodinâmico, baseados na literatura médica (*guidelines*). Após a elaboração dos critérios a equipe de acadêmicos de medicina e enfermeira iniciaram a caracterização da fila para termos uma ideia mais real, foram realizadas 396 ligações, para os pacientes que estavam catalogados em uma “lista de espera”, para realização do estudo urodinâmico. O questionário aplicado foi baseado na classificação urofuncional para realizar as entrevistas com os pacientes.

Como método de análise de dados, foi escolhido pelos experts em métodos de análise computacionais, o Método Analytic Hierarchic Process (Fuzzy AHP). Este método permite que situações que envolvem critérios subjetivos possam ser quantificadas, determinando scores para cada critério, desta forma o exame será indicado atendendo tanto as proporções do nível de urgência clínica, como as considerações sociais de cada paciente.

A tese foi desenvolvida em dois artigos, os quais explicam: as fases de desenvolvimento do projeto, a de criação do grupo disciplinar, determinação dos critérios de priorização, análise dos dados coletados, validação do método através de um estudo de simulação.

O presente estudo foi aprovado pelo comitê de ética do Hospital das Clínicas Universidade Federal do Paraná (HC-UFPR) sob o CAAE 85051918.2.0000.0096.

2 JUSTIFICATIVA

Após elencarmos todos os problemas ocasionados pela falta de priorização da fila do estudo urodinâmico, este estudo se fez necessário para que pudéssemos de uma forma justa e imparcial, realizar o exame, minimizando os agravos à saúde dos pacientes, diminuindo stress e melhorando a qualidade de vida dos mesmos.

Dentro do contexto administrativo, a tomada de decisão por parte do gestor em saúde, não é uma tarefa fácil, pois os problemas de saúde, em sua maioria são complexos e subjetivos. As decisões são normalmente determinadas pela escolha de uma pessoa ou de um grupo de pessoas. Com a priorização dos critérios para a realização do estudo urodinâmico, o gestor terá subsídios para tomar a melhor decisão possível.

Este estudo vai também ao encontro aos princípios do Sistema Único de Saúde (SUS), foi criado a partir dos princípios de universalização, equidade, integralidade, regionalização, descentralização, hierarquização e participação popular (BRASIL, 1988, 1990). Destaca-se que a equidade (reduzir desigualdades) e a integralidade (atenção global às necessidades, correlacionando promoção, prevenção, tratamento e reabilitação), devem ser respeitadas dentro dos serviços de saúde.

3 OBJETIVOS

3.1 OBJETIVO GERAL

Desenvolver Scores de Priorização para realização do estudo urodinâmico.

3.2 OBJETIVOS ESPECÍFICOS

- Criar critérios para elaboração dos scores de indicação do exame.
- Hierarquizar critérios para priorização dos pacientes
- Buscar na literatura métodos de priorização de pacientes
- Validar resultados encontrados na aplicação do método Fuzzy AHP
- Proporcionar uma priorização imparcial para os pacientes na fila do estudo urodinâmico.

4 REVISÃO DE LITERATURA

Faremos aqui uma breve revisão de literatura, sobre priorização de pacientes em fila de espera em serviços de saúde, estudo urodinâmico e o Método Fuzzy AHP, apenas para contextualizar esta tese. A revisão mais detalhada pode ser encontrada nos artigos originários desta tese.

4.1 PRIORIZAÇÃO

A priorização de pacientes em filas de espera tem sido vastamente estudada devido ao aumento da população global e o grande número de pacientes que utilizam os sistemas públicos de saúde em todo mundo.

Em estudo comparando o método First In, First Out (FIFO), este método é o utilizado para realização do exame em questão, com um método de priorização utilizando critérios de priorização para cirurgia de catarata, reduziu significativamente os tempos de espera e uma economia substancial de recursos e tempo, em comparação com o sistema FIFO (COMAS et al., 2008).

Longos tempos de espera e outros problemas de acesso aos serviços de saúde são desafios importantes que os sistemas públicos de saúde enfrentam. A priorização do paciente poderia ajudar a administrar o acesso aos cuidados de saúde de forma equitativa. Com o desenvolvimento de ferramentas para priorização de pacientes (Patients Prioritization Tools [PPTs], Ferramentas de Priorização de Pacientes), confiáveis e válidos para serviços não urgentes, acreditamos que projetos mais padronizados precisam ser conduzidos e apoiados a fim de avaliar facilitadores e barreiras à implementação de tais inovações (DÉRY et al., 2020).

Em estudo realizado na Inglaterra, diz que os sistemas de saúde não possuem objetivos claros na alocação de pacientes nas filas de espera. As listas de espera são influenciadas pela disciplina da fila, pois tradicionalmente a seleção dos pacientes pode ser determinada por fatores como: as urgências médicas, prioridades profissionais e o tempo na fila, diz (MULLEN, 2002).

Longos períodos de espera agravam a situação clínica do paciente causando angústia e dor. Rahimi et al. (2016), enfatiza que um melhor processo de priorização contribui para melhor serviço oferecido ao paciente e diminui a mortalidade e agravos à saúde dos pacientes.

Rahimi et al. (2016), em estudo realizado com fila de espera para pacientes ortopédicos de um hospital no Iran, dizem que os critérios de priorização devem ser determinados pelos experts na realização do procedimento em questão e, também, dos demais membros da equipe. Os autores ainda ressaltam que, com relação a exames e cirurgias eletivas não se tem uma priorização adequada como se tem em transplantes, emergências e cuidados intensivos, porém recentemente os serviços de saúde tem utilizado mais e mais a pesquisa operacional para solução de problemas.

Solans-Domènech et al. (2013) desenvolveram uma escala linear para priorizar os pacientes para cirurgia eletiva. Os pacientes são pontuados em três dimensões principais: deficiência clínica e funcional, benefício esperado e papel social. Estas dimensões incluem oito subcritérios: gravidade da doença, dor (ou outros sintomas principais), taxa de progressão da doença, dificuldade em realizar atividades da vida diária, probabilidade e grau de melhoria, ser dependente sem cuidador, limitação para cuidar dos dependentes (se for o caso) e limitações na capacidade de trabalhar, estudar ou procurar emprego. Esta ferramenta tem a característica de ser universal, portanto, aplicável a todos os pacientes do sistema público de saúde catalão.

Baseados nestes artigos pudemos observar que a metodologia, os critérios estabelecidos e a maneira com que foram elaborados, vão ao encontro dos estudos publicados ao redor do mundo para a priorização de pacientes em filas de espera para qualquer procedimento na área da saúde.

4.2 ESTUDO URODINÂMICO

O estudo Urodinâmico tem sido considerado uma ferramenta bastante útil para o diagnóstico de patologias do trato urinário baixo (do inglês, Low Urinary Tract Symptoms [LUTS] – Sintomas do trato urinário inferior), incontinência, bexiga neurogênica, entre outros (COLLINS; WINTERS, 2014). Sendo assim, órgãos como a American Urological Association (AUA, 2020) e a Society of Urodynamics Female Pelvic Medicine e Urogenital Reconstruction (SUFU – WINTERS et al., 2012), publicaram em seus sites na internet *guidelines*, elencando uma série de indicações.

Tradicionalmente, o estudo urodinâmico tem sido usado para os seguintes cenários: identificar fatores que contribuem para a disfunção do trato urinário inferior e avaliar sua relevância, prever as consequências da disfunção do trato urinário inferior nos tratos superiores, para prever as consequências e os resultados da intervenção terapêutica, confirmar e/ou compreender os efeitos das técnicas de intervenção e investigar os motivos de falha terapêutica (COLLINS; WINTERS, 2014).

Embora a literatura determine um conjunto de condições para a necessidade de realização o exame, ainda não há uma diretriz brasileira que padronize o atendimento considerando a realidade nacional e tais indicações médicas.

4.3 MÉTODO AHP

Com intuito de quantificar a preferência dos tomadores de decisão, foram desenvolvidos os métodos de decisão multicritérios, dentre estes métodos encontra-se o Analitic Hierarchy Process (AHP) concebido por Thomas Saaty na década de 1970 (SAATY, 1977).

Neste método, o problema da decisão é desagregado em critérios e estes estruturados em níveis hierárquicos do mais prioritário para o menos prioritário, facilitando assim a compreensão e a avaliação. Após se aplica um questionário ao tomador de decisão (ou grupo) e através de cálculos matriciais determina-se os pesos de cada critério. O diferencial deste método é a capacidade de conversão de dados subjetivos em algo quantificável. Diferentemente dos métodos estatísticos o AHP não necessita de tamanho de amostra, pois o seu propósito é o de mapear como uma pessoa (ou grupo) toma decisões.

O método Fuzzy AHP é uma adaptação do AHP original, onde são usadas funções para se codificar a linguagem natural, por exemplo quando um expert diz que o critério A muito mais importante do que o B. Esta palavra “muito” transformada em uma função nebulosa (Fuzzy) e são executados todos os cálculos originais do AHP usando tais funções ao invés de um número simples. O Fuzzy-AHP adiciona uma complexidade computacional ao método, mas para as entrevistas isso é feito de modo transparente, sem ônus para o pesquisador.

Jamshidi et al. (2015) utilizaram o método AHP para propor uma nova compreensão do risco baseado na estrutura de priorização para selecionar a melhor estratégia de manutenção para equipamentos médicos hospitalares como incubadoras, monitores, bombas de infusão dentre outros. Esta estrutura produz resultados precisos e confiáveis e não simplesmente uma ordenação. Foi possível com este estudo, selecionar a melhor política de manutenção dos equipamentos baseados no uso e importância de nível de complexidade de cada aparelho ou dispositivo. O autor ainda salienta que o risco baseado na estratégia de priorização é válido pois a instituição pode utilizar melhor a distribuição de recursos.

Em um hospital de Teerã desenvolveu-se um Clinical Decision Support System (CDSS) para doença cardíaca, com a aplicação do Fuzzy AHP. Este estudo compara pacientes submetidos a consultas médicas eletivas nas quais foram solicitados exames complementares de alto custo. Os mesmos pacientes foram priorizados com o método Fuzzy e apenas 20 de 100 pacientes incluídos no estudo, apresentaram doença cardíaca. Foram economizados centenas de dólares (NAZARI et al., 2018).

5 MATERIAIS E MÉTODOS

Esta tese foi realizada por artigos, sendo assim definiremos a metodologia utilizada para cada um dos artigos separadamente.

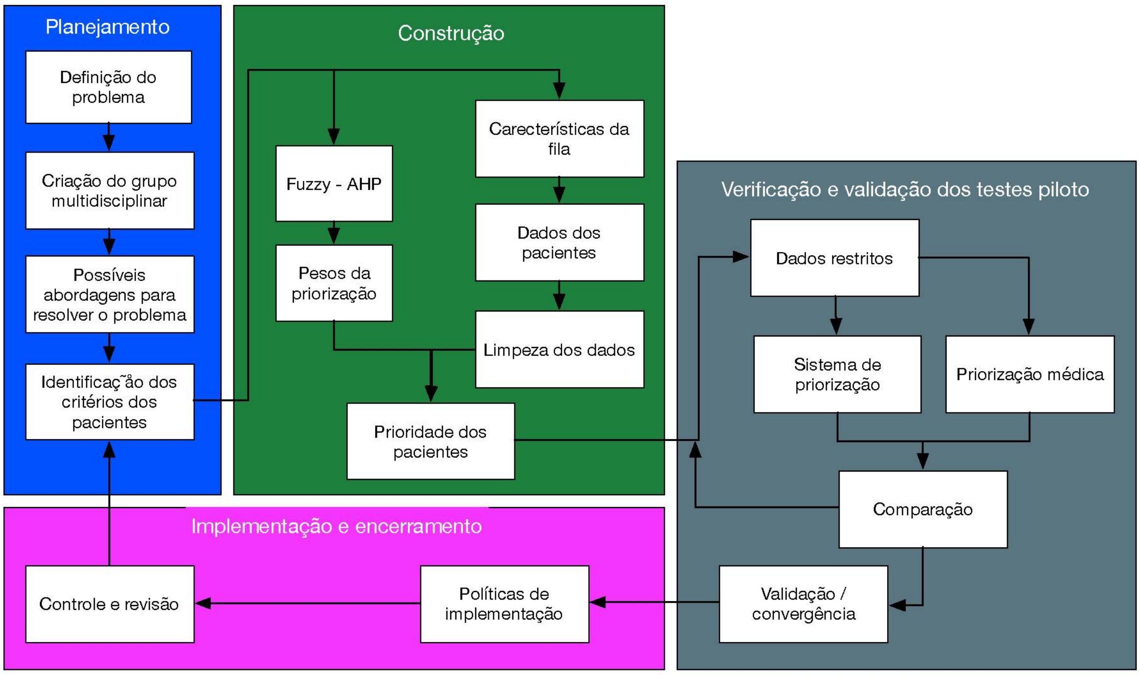
5.1 ARTIGO 1: PROJECT PLANNING FOR IMPROVEMENT IN A HEALTHCARE ENVIRONMENT: DEVELOPING A PRIORITIZATION APPROCH TO MANAGING PATIENTS' ACCESS TO THE URODYNAMICS EXAM

Esse artigo formaliza e explica as fases e passos seguidos, os quais identificam e avaliam critérios relevantes para elaboração dos scores de prioridade para o acesso de pacientes na fila do estudo urodinâmico.

Conforme descrito na introdução desta tese, foi criado um grupo multidisciplinar para encontrar a melhor solução para o problema da imensa fila do estudo urodinâmico.

Durante uma das reuniões com o grupo, foi proposto a utilização da metodologia de gestão de projetos, desenvolvida pela escola de administração da Harvard Business School (2016). Baseado nessa metodologia desenvolvemos a Figura 1, a qual determina alguns passos a serem seguidos independentemente do tamanho do projeto. Desta forma o projeto tem mais chances de sucesso.

FIGURA 1 – FASES DO PROJETO



Fonte: Extraída do artigo 1 – Pécora et al. (2021).

5.1.1 Fase de planejamento

Esta fase determina como o problema será resolvido, identificação dos colaboradores, função de cada um dos colaboradores, tempo, ferramentas utilizadas e custos.

5.1.2 Definição do problema

O problema definido com a direção do hospital foi: Como melhorar o fluxo de atendimento de pacientes na fila para realização do estudo urodinâmico.

5.1.3 Criação do grupo multidisciplinar

A equipe multidisciplinar, composta de médico urologista, enfermeiros, residente em urologia, acadêmicos de medicina, administrador e tecnólogo em tecnologia da informação. As reuniões eram semanais e um grupo de whatsapp foi criado para facilitar a comunicação entre os membros do grupo.

5.1.4 Possibilidades de resolução dos problemas

Durante as reuniões da equipe foram discutidas várias hipóteses para solução do problema. Percebeu-se que não seria tarefa fácil e houve então a oportunidade de inclusão no grupo multidisciplinar de um matemático computacional e um engenheiro, os quais agregaram outras competências ao grupo, trazendo inovação e melhor análise dos dados levantados pelo grupo.

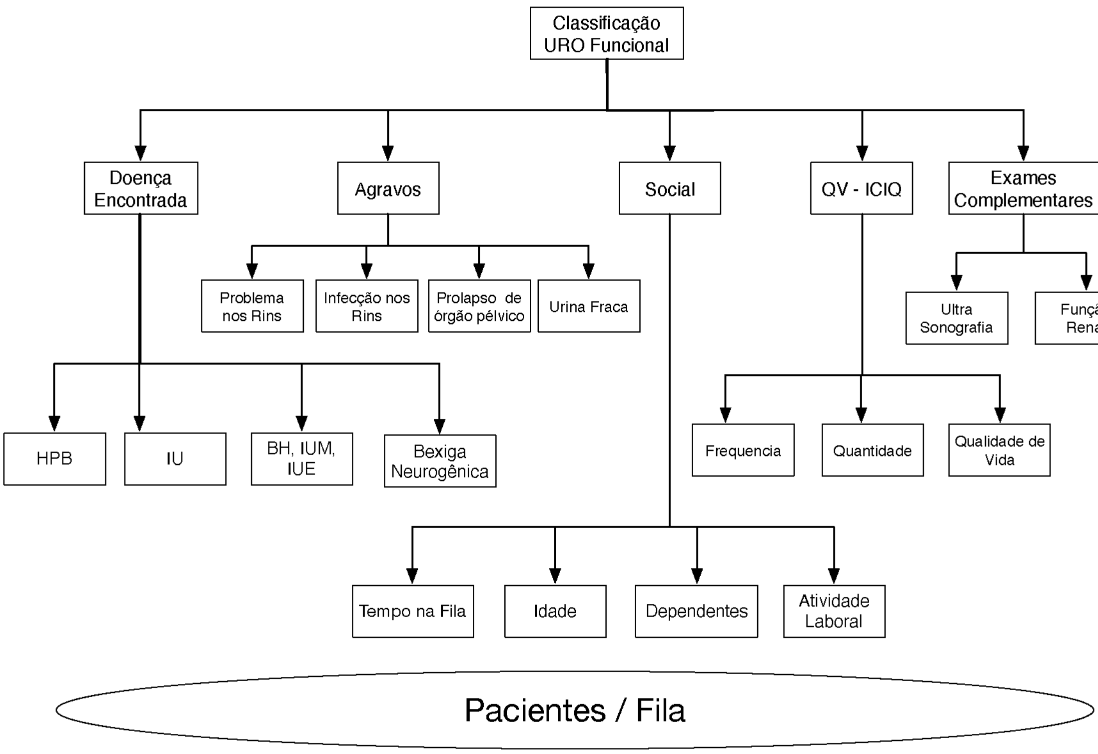
5.1.5 Identificação e elaboração dos critérios de prioridade

A partir das reuniões, foram atribuídas tarefas a cada um dos membros conforme a área de atuação e competência. O time da saúde, basicamente os médicos, estudantes de medicina e as enfermeiras, ficaram responsáveis pela definição dos critérios e subcritérios de priorização para a realização do estudo urodinâmico. Estes critérios foram estabelecidos com base nas definições e diretrizes para realização do estudo urodinâmico da Sociedade Brasileira de Urologia (2018). O grupo denominou estes critérios como Classificação Urofuncional (Figura 2).

O outro grupo, chamado de analítico, era formado por matemático, engenheiro e estatístico, que com base na literatura, determinaram que o método Fuzzy AHP seria mais adequado para determinação e cálculo dos scores de prioridade para cada critério estabelecido pelo grupo da saúde.

As constantes comunicações entre os grupos foi uma das chaves para o sucesso deste projeto.

FIGURA 2 – CLASSIFICAÇÃO UROFUNCIONAL



Fonte: Elaborada pela autora.

Após a definição dos critérios de priorização iniciou-se a aplicação dos questionários conforme o modelo AHP. Os questionários foram aplicados a 15 experts em Urodinâmica de diferentes regiões do Brasil, as entrevistas foram pessoalmente e via telefone, os experts assinaram Termo de Consentimento Livre e Esclarecido (TCLE – ANEXO C). O entrevistador fazia uma pequena introdução explicando ao entrevistado qual o objetivo do estudo e o método de análise. O questionário baseia-se em comparações pareadas. O entrevistador apresentava ao entrevistado dois critérios, perguntando ao expert, qual deles achava que seria mais importante para realização do estudo urodinâmico. O entrevistado poderia classificar os critérios em 0= equivalente, 1= pouco prioritário, 2= prioritário e 3= altamente prioritário, conforme Anexo A.

Após 15 entrevistas realizadas, os dados foram tabulados em planilha excel e encaminhado ao grupo analítico para realização dos cálculos através do método Fuzzy AHP, para atribuição dos scores de cada um dos critérios e subcritérios da Classificação urofuncional.

5.1.6 Fase de construção

A fase de construção foi executada pela equipe analítica, através do método Fuzzy AHP. As fases, cálculos e resultados da aplicação do método, estão todas descritas no artigo 1 desta tese.

5.2 FASE DE IMPLEMENTAÇÃO: ARTIGO 2: EVALUATION AND VALIDATION OF A NEW PATIENT PRIORITIZATION TOOL

Recentemente, o desequilíbrio entre a oferta e a demanda por serviços de saúde progrediu muito rapidamente, levando as listas de espera mais longas e tempos de espera maiores do que o período clinicamente recomendado. Portanto, foram propostas Ferramentas de Priorização de Pacientes (PPT), numa tentativa de apoiar os gerentes em suas decisões relacionadas à priorização dos pacientes e melhor administração das listas de espera.

A metodologia utilizada para gerenciar o acesso dos pacientes ao estudo urodinâmico, discute os processos de avaliação e validação das ferramentas de priorização de pacientes. O desenvolvimento desta ferramenta engloba 3 fases:

- **Fase 1:** Os experts identificam e acordam o conjunto de critérios considerados relevantes, o qual foi descrito na metodologia do artigo 1 desta tese.
- **Fase 2:** Esta fase é a fase de construção, na qual pesos foram calculados e atribuídos para cada critério, através do Método Fuzzy AHP, determinando a pontuação global de cada critério.
- **Fase 3:** Os problemas dos serviços de saúde são considerados complexos, por isso se faz necessária uma ferramenta de otimização. Além disso as listas de espera são dinâmicas, alguns pacientes chegam, outros são liberados após o tratamento recebido e alguns podem ter uma alteração do quadro clínico, mesmo já estando na fila de espera, sendo assim a lista deve ser reavaliada a cada mudança de situação.

Para validarmos este modelo de priorização, fizemos uso da metodologia de simulação. A simulação se preocupa em estabelecer até que ponto um modelo é uma representação precisa do mundo real, a partir da perspectiva dos usuários do modelo. Em nosso caso, trata-se principalmente da escolha dos critérios e subcritérios, sua estrutura, suas relações, sendo estas adequadas para reproduzir as decisões dos especialistas.

Para realização da simulação, foram entrevistados 10 pacientes do ambulatório de disfunção miccional, os quais já haviam sido referenciados para realização do exame. A entrevista foi baseada no questionário urofuncional e na coleta de dados do prontuário, os pacientes assinaram o Termo de Conscentimento Livre e Esclarecido Paciente (TCLE – ANEXO B).

Após a coleta, os dados foram transcritos em forma de história clínica, sendo considerado mais próximo da realidade médica e mais fácil de ser avaliado por eles. Seria como se o médico estivesse lendo o prontuário do paciente. Um exemplo de tal registro é:

> Paciente do sexo feminino, 25 anos de idade, bexiga neurogênica devido a lesão medular congênita, relata ter uma grande perda na atividade profissional devido à doença, não tem dependentes, mora com sua mãe. A paciente se aposentou devido à incapacidade. Ela relata uma grande perda de urina o tempo todo. Ela espera na fila por 14 meses para realizar o estudo urodinâmico. Sem doença renal, USG normal, creatinina de 0,3 e oxibutinina com melhora significativa dos sintomas. ICIQ = 21 (Entrevistado 1).

A simulação deste modelo iniciou com uma reunião com o médico chefe da urodinâmica, um médico residente em urologia, a pesquisadora e o matemático computacional. As 3 fases da simulação chamaremos de rounds:

- **Round 1:** Ordenação das histórias reais e comparação das mesmas com o PPT.
- **Round 2:** Reordenação pelos dois médicos das histórias reais e nova comparação com o PPT.
- **Round 3:** Avaliação de dados clínicos relevante, reordenação e nova comparação com o PPT.

ROUND 1: As histórias dos pacientes foram dispostas aleatoriamente em cima da mesa, para cada um dos experts, que tiveram que ordenar as histórias dos pacientes por ordem de prioridade e não puderam comparar as respostas. Após ordenarem as respostas, elas foram comparadas com as respostas do questionário

AHP, chamado aqui de ferramenta de priorização de pacientes, PPT respondido no início da pesquisa.

Ao comparar as respostas do chefe com a do residente em relação as histórias reais dos pacientes, observamos que foram similarmente ordenadas. No entanto a comparação entre a PPT do chefe com a priorização das histórias reais havia discrepância importante, isso também aconteceu com o residente.

Foi então permitido ao chefe e ao residente que comparassem a ordem das histórias reais, dando origem ao Round 2.

ROUND 2: Ao reordenarem as histórias reais, os experts separaram os pacientes em: alta, média e baixa prioridade, conforme os critérios descritos na classificação urofuncional. Nova comparação entre a ordem das histórias reais e do PPT do chefe foram realizadas. Mesmo com estas comparações ficou comprovado que apesar da priorização das histórias reais estarem mais próximas do PPT chefe, ainda assim tínhamos discrepâncias a serem resolvidas e precisávamos encontrar o motivo dela.

ROUND 3: Uma nova avaliação minuciosa de todas as histórias clínicas foi realizada, observou-se que uma das condições clínicas de um paciente (cisto renal), não era um dado tão relevante quanto se pensou, isso pode ser considerado um “erro” ou inacurácia do dado, levando a um erro de pontuação no PPT. Outro dado importante encontrado foi que pacientes com Bexiga Neurogênica (BN) não podem entrar na fila comum de exames. Esses pacientes devem estar em uma fila separada, para que possam realizar o exame conforme o preconizado nos *guidelines*, mínimo de uma vez ao ano. Pacientes portadores de BN, tem uma condição delicada, sendo propensos a maior incidência de doença renal grave.

Nova comparação entre as histórias clínicas e o PPT chefe foi realizada, com nível de discrepância aceitável entre os pacientes.

Após esta última avaliação, concluiu-se que classificar os pacientes entre alta, média e baixa complexidade foi muito útil, pois desta forma o PPT produz uma classificação muito precisa de pacientes com alta e baixa prioridade. Além disso, os pacientes classificados como de prioridade média apresentaram pontuações muito semelhantes, pelo que, na prática, deveria haver tempos de espera semelhantes.

Durante o processo, os experts também descobriram que pode haver diferenças entre a importância que um critério deve receber e a importância real que o critério recebe nas suas decisões.

Após todo o processo, os dois experts concordaram e expressaram confiança nos resultados produzidos pela ferramenta e na recomendação para uma implementação prática.

Esta metodologia demonstrou-se efetiva para avaliar uma Ferramenta de Priorização do Paciente (PPT), desenvolvida para gerir e aprimorar o fluxo de acesso dos pacientes ao estudo urodinâmico no serviço de urologia do Hospital de Clínicas da Universidade Federal do Paraná.

6 ARTIGOS

Conforme citado anteriormente foram escritos dois artigos como desenvolvimento da tese. O primeiro já publicado na revista Journal of Modern Project Manegement 2021, inserido na sua íntegra na formatação original com autorização do editor Osmar Zózimo. O segundo submetido à revista Digital Health em fevereiro de 2022, aguardando resposta, também inserido na tese na sua íntegra.

6.1 ARTIGO 1

Project Planning for Improvement in a Healthcare Environment:

Developing a prioritization approach to managing patients' access to the Urodynamics exam

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Abstract: The first-in first-out rule does not seem the most appropriated to manage the access of patients to health exams or services such as, for example, surgery. Indeed, each patient has his/her level of urgency and, furthermore, the utility that each patient retires from the service differs according to several clinical but also risk and social-related aspects. The decision of which patient to prioritize is tough because, in the current context, where capacity is much lower than demand, choosing one patient means to delay others. Thus, this paper proposes a project methodology to prioritize patients into a Urodynamic service. The methodology, developed by a multidisciplinary team, is applied in a public hospital in Brazil, taking into consideration clinical and social criteria. We interviewed Urodynamics specialists, and a Fuzzy-AHP method was used to compute the weight of each criterion. Our preliminary results show the potential of the proposed methodology and methods, and that not only for the described case, but for other health services facing similar problems.

Keywords: Prioritization, Urodynamics, Project, Fuzzy AHP, Healthcare

1. INTRODUCTION

The Urodynamic procedure of Hospital de Clínicas (HC) is a service with a substantial volume of exams, as well as attending patients from the urology outpatient clinic, and it also receives patients from other specialties such as gynecology and coloproctology. During recent years, the waiting list has grown to reach currently approximately 3,000 patients and an average waiting time of 3 years.

The HC's Ombudsman, who receives patients' complaints and compliments, has reported that urodynamics is the service of the urology unit that receives the most complaints, mostly because of the delays of the exams, which suggests that the hospital's capacity for this particular service is below the actual demand.

Hospital managers have therefore decided to create a team of experts to improve the patients' flow at the Urodynamics Service. The team includes members of all the professional categories involved in the service. Several meetings were organized to discuss the manner in which the service manages its patients' waiting list and, in particular, how patients waiting for the urodynamic procedure were prioritized, which lead us to the formulation of this research's objective: how to develop an uro-functional score for risk classification of patients who requests a urodynamic exam?

This paper formalizes and explains the phases and steps to identify and assess the main relevant criteria to elaborate a risk score to prioritize patients' access to a medical exam, named urodynamic procedure. It focuses on the managerial aspects of the project rather than the methodological ones (i.e., the multicriteria decision-making approach) that are out of the scope of this publication. The paper is structured as follows. The next section presents some theoretical background on the considered medical procedure and reports related works on decision-making applications in healthcare; Section 3 presents the applied methodology while current results are reported in Section 4. Finally, Section 5 presents our conclusions and sketches of the next steps of the project.

2. THEORETICAL BACKGROUND AND PREVIOUS RELATED WORKS

This section is divided into three parts, the first one being devoted to the Project Management's methodology used in this research, the second one providing some basic background on urodynamics exam, and the last one presenting scientific works that have applied the AHP methodology to healthcare management problems. It is not the purpose of this section to be exhaustive concerning the literature but to present the theoretical background of this work.

Harvard Business School (2016) identifies four main phases of project management, which should be used independently of the project's size, from a simple website to the construction of a car, or the determination of the prioritization for a very complicated exam in a public hospital. The four-phases are:

1. Planning Phase: Its primary goal is to determine the problem to be solved, identify the collaborators, the function of each one within the group, define spaces, time, tools, and costs. The definition of objectives, the determination of the scope, resources, and tasks that each collaborator will execute must be well defined. Underestimation of time and money may cause, many projects fail. Still, within the planning phase, the Harvard Business School (2016) suggests to initiate the analysis of the project's trade-offs – time, cost, and quality – that typically dictate the project's solution space.
2. Build-Up: It is the construction phase, where the coordinator must elect the group's members, defining tasks according to the ability of each of the participants, planning assignments for each one, creating a realistic scale of time and resources. At this stage, meetings are also organized to return to the established objectives and to the tasks performed by the participants. It is also at this stage that we must determine the costs with personnel, training, travel, supplies, among others.
3. Implementation Phase: It is time to put the project into action. This is the most rewarding phase of the project and sometimes the most frustrating. At this stage, rapid meetings should be held to monitor and control budgets, adjust dates and scales, exchange information, manage problems both related to the development of the project, and personal problems of employees. Evaluate the project results, reorganize efforts in the latter case to close the project.
4. Closeout: Once the project has been completed, hold a meeting with the collaborators to recognize the efforts and accomplishments of the team. Special attention is given to discuss "learned lessons". This time is for discoveries and not for criticizing or blaming some of the contributors.

Urodynamics, also known as a urodynamic study, is the term that describes a set of tests that allows evaluating the transport, storage, and elimination of urine, especially in cases of complaints of lower urinary tract symptoms (MONTEIRO, 2012). The most common evaluations include filling and bladder storage through filling cystometry and urethral pressure profile, elimination of urine through the bladder through uroflowmetry and voiding study, and transport of urine. Besides, it is possible to perform, along with these steps, electromyography in order to evaluate the urinary sphincter (MAITIN, 2016).

Urodynamics has been considered a handy tool for the diagnosis of LUTS (Low Urinary Tract Symptoms), incontinence, neurogenic bladder, among others (COLLINS, 2014). Thus, the American Urological Association (AUA) and the Society of Urodynamics Female Pelvic Medicine and Urogenital Reconstruction (SUFU) published guidelines to the use of this test, listing a series of indications. Traditionally, urodynamics has been used to the following scenarios: identifying factors that contribute to lower urinary tract dysfunction and assessing its relevance, predicting the consequences of lower urinary tract dysfunction and outcomes of the intervention confirm and understand the effects of intervention techniques and investigate the reasons for therapeutic failure (COLLINS, 2014).

Although the literature suggests a set of conditions justifying the need for this exam, there is still no Brazilian guideline that standardizes care considering our social reality and medical indications. However, the literature proposes several prioritizations or waiting lists management schemes used in other medical specialties.

Déry et al. 2020, in a systematic review on Patient Prioritization Tools (PPT), states that long waiting times and other problems of access to healthcare services are key challenges that public healthcare systems face. Patient prioritization policy could help to manage access to care equitably. Their findings suggest that generic criteria, such as non-clinical or social factors, could be added to condition-specific criteria in PPTs to represent more fairly and precisely patients' needs to receive healthcare services. Patient prioritization is a strategy used to manage healthcare services access. The PPT could help ease the patient's prioritization decision process in an explicit, transparent, and fair manner. Other advantages associated with PPT use were identified, mostly related to the acceptability of the tools by clinicians and increased transparency and equity for patients. (DÉRY et al. 2020)

Mullen (2002) studied waiting list management in UK, and concluded that the UK's health systems do not have clear objectives in placing patients in waiting queues. To the author, waiting lists are influenced by the discipline of the queue, since traditionally, the selection of patients can be determined by factors such as medical urgencies, professional priorities and time in the queue. Waiting lists have a fast growth when resources are scarce, and rationing for time is better than price rationing, (Mullen, 2002). The downside is that long waiting periods aggravate the patient's clinical situation causing distress and pain. Viberg et al. (2013) conducted a study on waiting lists from 23 countries, and concluded that waiting lists are a severe health policy issue and that institutions have tried to remedy this problem through different methods of evaluation.

Rahimi et al. (2016) proposed a prioritization framework for orthopedic patients in a hospital in Iran. The authors emphasize that although prioritization and triage approaches exist for patients waiting for transplants, emergency cares, and intensive cares, there is a lack of adequate prioritization systems and tools for elective exams and surgeries. They also insist on the fact that the prioritization criteria should be determined by the clinical experts, but that other stakeholders among which patients and their families, must participate in the process. Finally, they report that surgeons that participated in the study concluded that the framework produces a precise and reliable prioritization that is more effective than the prioritization method currently in use.

In decision-making theory, some issues are subjective and determined by the choice of people or a group of people. As a simple example, the purchase of a house, where price, size, and location would be criteria for the purchase or not of the property. Price and size are objective or quantifiable criteria, but the definition of "a well-located home" is different for each person. Due to the subjectivity and the personality of this decision, it becomes a characteristic of the decision-maker. In healthcare, we have these types of subjective decisions, too; as the prioritization of a patient to have surgery or exam, or the prioritization of a particular surgical specialty to use an operating room in the Surgical Center.

In order to quantify this subjective preference of the decision-makers, the multi-criteria decision methods were developed, among them the Analytic Hierarchy Process (AHP) designed by Thomas Saaty in the 1970s (SAATY, 1977). In this method, the decision problem is disaggregated into criteria, and these are structured in hierarchical levels which facilitates their understanding and evaluation. After applying a questionnaire to a person (or a group) that will perform the decision, and using matrix calculus, the AHP is able to determine the weight of each criterion. The main feature of this method lays in the ability to convert subjective opinions into quantitative data. Unlike statistical methods, the AHP does not require sample size because its purpose is to map how a person (or group) makes decisions.

Muhlbacher and Kaczynski (2016) applied the AHP to identify and evaluate the relevant decision criteria of physicians regarding the drug treatment of functional dyspepsia and motility disorders. Attributes such as the onset of action, reduction of symptoms, and side effects should be examined to test their relevance to health decision-makers. Applying the AHP methodology, the study concluded that the following criteria were found to be the most relevant and their relative importance (weights): reduction of abdominal cramps (0.302), reduction of epigastric pain (0.250), and time of onset of action (p: 0.117). Rahimi et al. (2016) use AHP in conjunction with other Operational Research techniques to prioritize patients in an orthopedics' service. Otay et al. (2017) carried out research in 16 hospitals in Istanbul that used the Fuzzy AHP method for performance evaluation. In this problem, uncertainty and subjectivity is an unavoidable component of the decision-making process. As part of their evaluation, they chose to transform the answers coded in Fuzzy linguistic states to a crisp number.

Jamshidi et al. (2015) used the AHP to consider the risk into prioritization decisions. Their study concerned how to select the best maintenance strategy for hospital medical equipment such as incubators, monitors, infusion pumps, among others. Their proposal produces accurate and reliable results and not merely an ordering. They prove to be possible to select the best maintenance policy of the equipment based on the importance and the level of complexity of each device.

Nazari et al. (2018) developed a Clinical Decision Support System (CDSS) for heart diseases in collaboration with a hospital in Tehran, Iran. The CDSS was intended to identify patients with a high risk of heart disease. In their study, 100 patients were evaluated by the CDSS, and the results compared to the diagnostics made by professionals. Eighty-one of the professional diagnostics required further high complexity exams, to conclude that only 20 of the patients had heart diseases. For the same 100 patients, the CDSS which encompasses Fuzzy-AHP technology, suggested further exams to only 26 patients including the 20 patients that were finally confirmed as suffering heart diseases, confirming the potential of CDSS to reduce the hospital workload and to achieve a more efficient use of the resources.

3. THE METHODOLOGY

The primary goal of this project is to provide an unbiased prioritization score for patients waiting for the urodynamics' test. As it was said before, there are currently more than 3000 patients on the list, so waiting times for the test are too long. To mitigate this problem, a multidisciplinary team was put together; it was agreed that the methodology to solve the problem would be divided into four phases, following the Harvard Business School (2016). A team of healthcare professionals, mostly physicians and nurses, was responsible for defining the prioritization criteria that should be used to assess the needs of each patient. A second-team composed of Mathematicians, Engineers, and Statisticians was in charge of computing the weights of the criteria defined by the Healthcare Team.

Currently, the project is entering into the Implementation Phase, where the Healthcare Team will analyze a pilot sample of patients. Only after this validation, the full-scale implementation will take place. It is essential to notice that even after the implementation, a cycle of control and adaptation of the weights and criteria might be necessary to fine-tuning of the prioritization tool. It is also important to stress that once this methodology will be validated, it will be ready to be adapted to any other waiting list in the hospital.

Figure 1 shows the steps of the proposed methodology, starting from the Planning Phase, where a literature review lays the basis of the steps of our project, the methods of prioritization, and the clinical criteria were defined. In the Build Up phase, the data were acquired, treated, and a proposal of weights for each criterion and a sample of prioritization are the main output. In the Implementation and Close-Up phases, this sample is analyzed by the Healthcare Team and once validated, the implementation will start. It is worth notice that the criteria and the weights may be revised until convergence is found.

3.1 Planning Phase

The planning phase of a project seeks to define its fundamentals: what problem needs to be addressed, who will be involved, and what will be done (Harvard 2016). The main problem of this project is clearly stated, the size of the queue and the resulting waiting times for the patients needing

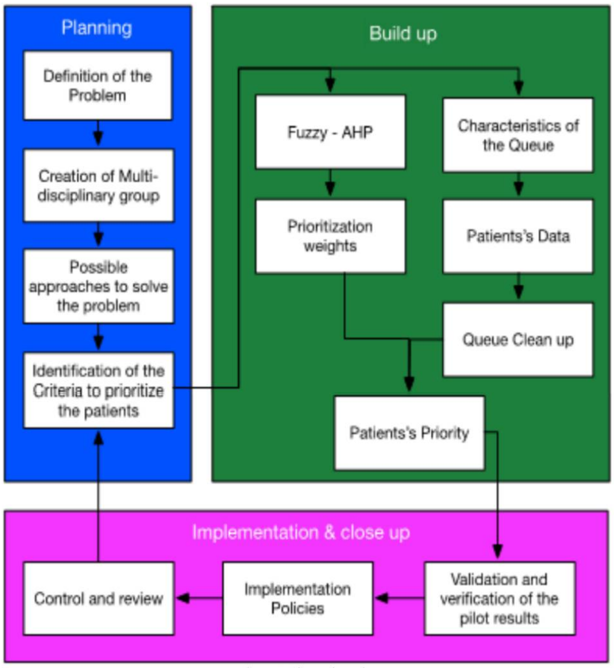

Figure 1 – The project phases.

urodynamics. The stakeholders of the project are the patients, the medical team, and also the administrative team. The project objectives are: identify, from all the patients in the list, the ones who really need to be there, and for the remaining patients, prioritize from the most to the least urgent using an uro-functional risk score.

3.1.1 Creation of the uro-functional multidisciplinary group

A multi-professional research group, containing professionals from all the stakeholders, was constituted to plan this project, from the identification of the objectives to the indication of the urodynamic risk score in the Clinical Hospital of the Federal University of Paraná (UFPR). The group has 13 professionals including a Urology Medical Professor, a Urological Physician, Medical Academics, Statistical Academics, Hospital Nurses, an Information Technology Technician, and a Business Administrator. After their first meeting, the group decided to invite analytics professors from the Business Department. All the members are related to the Federal University of Parana.

During the first phase, the research group met once a week for discussion and elaboration of the project, including the evaluation criteria, as well as other essential subjects according to the need of each participant of the project. Constant communication between the group members was assured by instant message groups; we believe that the interaction between the Analytics Team with the Healthcare team was one of this project's key to success.

3.1.2 Risk Criteria Mapping

The risk criteria are guided by the definitions of the Brazilian Society of Urology (2010). At this point, each member of the group was responsible for carrying out a part of the work, making the necessary considerations to create the criteria risk mapping, which attends to the clinical necessity but also to the data necessity. All the criteria were categorized by the clinical importance but also by the availability of the data, once it is unworthy of having criteria that we did not have access to the data. Other essential parts of this project planning included the identification of the methods to be used, the essential data for medical evaluation of the need for the exam, the administrative steps to be followed according to institution norms, and the statistical and information technology to be used to the data analysis. This diversified team with complementary strengths made the discussions very dynamic and productive. It is worth emphasizing that the team put together people in charge of data analysis, people offering direct assistance to patients, and even people performing administrative tasks.

The planning phase was closed with the criteria mapping, which was elaborated under the coordination of the urologist medical professor, and that takes into account both the needs of each pathology and the social aspects of the patients. The mapping leads to a criteria structure, depicted in **Figure 2**, and that hereafter will be referred to as Urofunctional Structure. It is composed of five main criteria: Disease Found, Health Problems, Social condition, Quality of Life, and Complementary Exams. Each of these main criteria includes two to four sub-criteria. The next paragraphs describe the main criteria and the sub-criteria they encompass.

Disease Found – identify and consider specific symptoms that can be observed in patients referred for a urodynamics test. Includes:

- **Benign prostatic hyperplasia (BPH)** is the most common benign neoplasm in men. It is the clinical manifestation of prostate enlargement, causing urinary symptoms that harm the quality of life of the population. The statistics show that from 55 years, 25% of men have complaints about some urinary symptoms.
- **Urinary Incontinence Refractory** (UI): Urinary incontinence is already treated clinically with physiotherapy, drug therapy, psychology, among others, unsuccessfully.
- **Stress Urinary Incontinence** (SUI): is defined as involuntary loss of urine during exertion such as exercise, coughing, or sneezing.
- **Mixed Urinary Incontinence** (IUM) is the combination of urinary urgency and stress urinary incontinence.
- **Overreactive bladder** (OB) is a syndrome characterized by the symptoms of urinary urgency with or without urge incontinence, usually accompanied by increased voiding frequency and nocturia (urinating at night) with no local or metabolic cause.
- **Neurogenic Bladder** (NB) term created to describe vesical-sphincter dysfunctions that affect patients with diseases of the central or peripheral nervous system. Neurogenic bladder carriers may have changes in the voiding pattern in the filling and bladder emptying phases.

Health Problems – describes common symptoms or comorbidity observed in patients referred for a urodynamics test. Includes:

- **Kidneys Problems**: swelling in the leg, little urine during the day - IR (lower limb edema; low urine volume <500ml in 24hrs).
- **Kidney Infection**: Pyelonephritis, recurrent infection in the bladder or urine with lumps - recurrent Low Urinary Tract Infection.

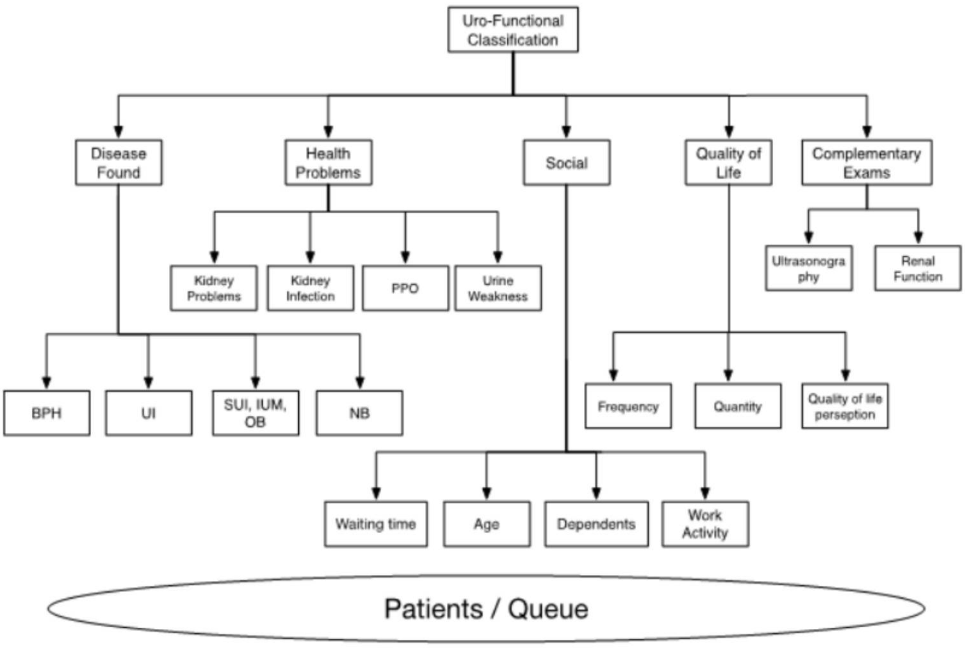

Figure 2 - AHP Structure applied to the service of urodynamics.

- **Pelvic Organ Prolapse** (PPO): it is a herniation of the pelvic organs through the vagina. It is a prevalent condition of low morbidity and mortality, but it affects women in their daily lives, sexuality, and physical activity. The prevalence of this condition is close to 22% in women between 18-83 years of age, varying up to 30% in women aged 50-89 years.
- **Urine Weakness** (UW): Urination is an act performed comfortably and effortlessly; its appearance involves difficulty in bladder emptying of inflammatory, neurogenic, infectious, or more commonly, obstructive origin.

Social Condition – relates to the personal and family environment of the patient and his specific context. In particular, the following sub-criteria were suggested as relevant for prioritization:

- **Waiting time**: the waiting time in the queue characterizes when the patient has entered the queue, in that year, since we have a queue of approximately three years.
- **Age**: The age of the patient.
- **The number of dependents**: we took into consideration not only children but any person who depends on this patient.
- **Impact on labor activity**: in which the patient works, needs physical strength, works more seated, does a work activity that requires traveling, among others.

Quality of life - In order to determine the quality of life, the ICIQ: International Consultation on Incontinence Questionnaire-Short-Form (ICIQ-SF) questionnaire is applied in patients with urinary incontinence. It is a simple, brief, and self-administering questionnaire chosen to be translated and adapted to our culture by rapidly assessing the impact of UI on quality of life and qualifying urinary loss of patients of both sexes. In this criterion, the frequency and amount of urinary loss were considered.

Complementary exams – describe the results of the two most common exams to evaluate the Renal condition.

- **Ultrasonography**: imaging exam that evaluates the following criteria: reduction of renal cortical thickness, cortical scarring/retraction, pelvic-incisional dilatation.
- **Renal Function**: Creatinine Clearance Calculation (glomerular filtration rate).

3.2 Build up Phase

The build-up phase is divided into two parallel processes related to the data source. The first process, aimed to find the weights for each criterion, requires the collection of data and opinions provided by the physicians. The second axis deals with patients' assessment and therefore focuses on the acquisition of patients' data. Although both processes deal with data collection, they are very different in nature. In the first axis, the goal is to extract and formalize knowledge from experts opinions by means of multicriteria methods. The second axis concerns mainly structuring and analyzing patients' files.

3.2.1 Physician data

After determining the criteria to be evaluated, and their hierarchical structure, we need to attribute weights for each criterion. To this end, we chose the Fuzzy AHP (Analytical Hierarchy Process), an extension of the original Saaty's AHP (Saaty, 1976). This method allows situations involving subjective criteria to be quantified, determining scores for each criterion.

The data collection for the Fuzzy AHP was done using an electronic questionnaire listing all the pair-wise questions to evaluate the relative importance of each criterion with respect to the others, as instructed in (Saaty, 1976) and the hierarchical tree of **Figure 2**. Before applying the questionnaire, a pre-test was administrated to the urology resident in order to identify the need for changes or adaptations, as well as how much time it would require to be completed. Only after this, the full-scale questionnaire was conducted, both personally and by telephone, with the most diverse experts in urodynamics in Brazil. The interviews targeted urologists but also gynecologists, since these two specialties deal with urinary incontinence. In the end, answers from 15 experts to the AHP-Fuzzy questionnaire were successfully collected.

The interviewer explained briefly to the interviewee the objective of this study and the method used to analyze it. The questionnaire focused on the pair-wise comparison, i.e., the relative importance that the expert gives to one criterion with respect to each of the others; the interviewee has thus presented combinations of each two criteria and was required to express which one and to which extend, one criterion seemed to him more important than the other for established patients' priorities. The original Saaty's scale goes a degree of preference ranging from 1 to 9. Having nine different degrees of preference, maybe very confusing for the respondent, therefore we decided to map Saaty's scale into four fuzzy linguistic states represented by triangular functions. Therefore, each interviewee could qualify the relative importance between of a criterion with respect to another one by using a fixed qualitative scale including the terms "equivalently important", "a little more important than", "more important than", and "clearly more important than", which are related to the pertinence fuzzy functions depicted in **Figure 3**. The state "Equivalent" is represented by the function Triangular (1/4, 1, 4), Low Preference by Triangular (1, 3, 6), Priority by the function Triangular (2, 5, 8) and finally Clearly by Triangular (4, 7, 9).

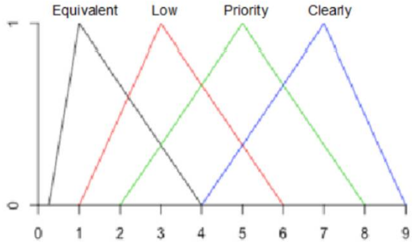

Figure 3 - Fuzzy Mappings

After the data collection and using the fuzzy-AHP process described in Srichetta and Thurachon (2012) which complements the method described in Chang (1996), the weights for each criterion were calculated. **Table 1** reports the numerical results produced for our problem, where the two first columns are the description of the three structures, and the last two columns the weights found. The main criteria with the highest weight is Health Problems, which receives 28.81% of the total weight, followed by Complementary Exams (24.90%) and Disease (21.45%). The criterion Social received a weight of only 8.38%. Unsurprisingly, clinical criteria received higher weights than the social one. As for the sub-criteria, it is worth recalling that the sum of the weights of all the sub-criteria under the same parent criterion must equal the parent's weight. The sub-criteria considered as the most relevant were Ultrasonography and Renal Function which received weights of 12.49% and 12.41%, respectively. Followed by Kidneys Problems (10.28%). The criteria considered as the least important belong to the main social criterion: Dependents (1.95%), Age (2.09%), and Impact on labor activity (2.09%).

Criteria	Subcriteria	Weight	Weight Sub
Disease		21.45%	
	BPH		4.00%
	(UI)		5.94%
	SUI,IUM,OB		3.03%
	NB		8.48%
Health Problems		28.81%	
	Kidneys Problems		10.28%
	Kidney Infection		8.40%
	PPO		5.21%
	UW		4.91%
Social Condition		8.38%	
	Waiting time		2.27%
	Age		2.09%
	Number of Dependents		1.95%
	Labor Activity		2.09%
Quality of life		16.46%	
	Frequency or Urinary Incontinence		4.80%
	Overall Impact of Urinary Incontinence		5.41%
	Amount of Leakage		6.26%
Complementary exams		24.90%	
	Ultrasonography		12.41%
	Renal Function		12.49%

Figure 2 - AHP Structure applied to the service of urodynamics.

3.2.2 Patients' Data

In most of data analytics projects, the part of structuring and organizing the data is usually the one that takes a longer time and deep effort. This project was no different. We started with a sample of 322 patients' files randomly drawn from a list with more of 3000. From those 322, 87 patients were successfully contacted, and 86 agreed to answer the questionnaire, while one refused, 225 were classified as "does not exist/does not answer the call" and 10 where dead. Among the 86 collected responses, there was a predominance of women (81%); 54 of the 86 interviewed were over 60 years old (62,7%). This work is vital to have a real view of the waiting list. This is an ongoing part of the project, and the careful review of each patient should be continuously done before we launch the full-scale implementation.

Once the patients' data were collected, we used the weights produced in Section 3.2.1 to compute a priority score for each patient. The priority list is simply obtained by sorting them according to them to their score in decreasing order.

3.2.3 Patients' Priority and validation

The preliminary priority list produced by the Fuzzy-AHP method was successfully validated by the chief medical officer of the urology department, after a thorough analysis of the patients' files and their respective priority in the list. Having a fully functional and validated algorithm capable of prioritizing a sample of patients closes the build-up phase of these project.

The implementation phase will take place in the months to come. In a nutshell, this phase will include an online platform accessible to all the concerned personnel, training of these personnel in the use of the prioritization platform, full-scale implementation of the Urodynamics queue, including new patients and a daily update of the queue situation.

4. CONCLUSION AND FUTURE WORKS

This work proposed a methodology to elaborate a computer-based prioritization tool to manage the patients' access to an elective exam named urodynamics. The importance of this work lays in the fact that, in the case that we studied, more than 3000 people currently wait to access this exam. The long waiting times strongly affect the day to day of the patients, hence deteriorating their quality of life. The prioritization process aims to give quicker access to those that need more service. In the prioritization process, we considered criteria related to clinical, social and quality of life aspects. As expected, the three clinical criteria (Disease, Health Problems and Complementary Exams) are the most important in the decision-making, and together they receive weight or relative importance of 73.07%. The criterion Quality of life receives a weight of 18.99%, and finally, the Social criterion receives a weight of 7.94%. The approach and the results produced by the proposed Fuzzy-AHP method have been validated by the clinical chief of the Urology department. The implementation of a prioritization tool constitutes the next step of this project that aims to contribute to better use of the healthcare system's resources.

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6.2 ARTIGO 2

• Evaluation and validation of a new Patient Prioritization Tool

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Abstract. As times to access health services have significantly increased during the last years worldwide, strategies and tools to better manage patients' waiting lists have gain interest from research. Computer-based Patient prioritization tools, referred to as PPT, aim to manage access to care by ranking patients in waiting list equitably and rigorously so that higher priority patients will be treated ahead of those with a lower priority, regardless of when were added to the list. Although the literature devoted to PPT is rich, works describing the transition of research prototypes of PTT to field applications are rather scarce. This paper presents and discusses the evaluation and validation process of a PPT to assess the extent to which the tool can produce improved outcomes and a lack of unintended consequences. This paper illustrates how the proposed validation process contributes to the improvement of the tool, develops the confidence of future users, and also helped to better understand the challenges and difficulties related to the experts' evaluation process.
Keywords: patient prioritization tools, waiting list management, new tool validation, validation and verification.

1. Introduction

The number of decision support tools deployed to support activities related to the delivery of health services has increased significantly in recent years. Aiming at reducing clinicians' workload and increasing efficiency of administrative tasks, the decision support tools have shown potential in predicting patients' health trajectories, recommending treatments, guiding surgical care, monitoring patients, and supporting efforts to improve the health of a community. However, as it was pointed out by (Maddox et al., 2019), "innovations in medications and medical devices are required to undergo extensive evaluation, often including randomized clinical trials, to validate clinical effectiveness and safety."

In the last years, the unbalance between the offer and the demand for health services have progressed very fast, leading to longer waiting lists and waiting times that are longer than the clinically recommended period. If we consider elective surgeries, by the end of 2019 over 27 000 patients were waiting for a surgery for more than one year in Portugal, while in Australia the percentage of elective patients waiting for more than one year oscillated between 1.7 and 2.8% between 2015 and 2020. The situation has considerably worsened during the 2020-21 years, as most of health resources had to be devoted to support the COVID-19 pandemic needs. For instance, in the United States a decrease of around 35% in operating room case volumes has been observed between March and July 2020 when compared to the prior year. Such disruptions, which can unfortunately be generalized to most of the medical and diagnosis services, increase the patients backlogs and, according to the authors, hospitals in the United States would need to work at 120% of its historical throughput during ten months to be able to work through two months of additional surgical demand in less than one year.

In this context of higher demand and longer waiting times to access healthcare services, the need for Computer-based Patient prioritization tools, referred to as PPT, has accelerated. PPT aim to manage access to care by ranking patients equitably and rigorously in waiting lists based on criteria, so that those with urgent needs receive services before those with less urgent needs. Although PPTs have been widely studied, only few works have attempted to experiment implementation and more precisely the constructs determining the successful implementation of a new practice or an innovation into clinical practice. A recent study on the acceptability of new technologies and services in healthcare showed that a substantial proportion of users was hesitant to new technologies and AI application, mainly because of concerns about the accuracy and security of these services.

This paper presents and discusses the evaluation and validation processes of a PPT. These early stages in the implementation process seek indeed to demonstrate the extent to which the tool can produce improved outcomes and a lack of unintended consequences. The PPT was conceived to manage patients' access to the urodynamic test, referred to as UT, in the urology service at the Hospital de Clínicas of the Federal University of Parana, Brazil. The urodynamic test (UT) is an interactive diagnostic study of the lower urinary tract, composed of several tests that obtain functional information about urine storage and emptying (Society of Urodynamics Guideline, 2012). This exam is an essential tool in diagnosing low urinary tract pathologies, urinary incontinence, neurogenic bladder, among others (Collins & Winters, 2014). Requests for UT arrive from patients at the urology service, but also from other specialties such as gynecology and coloproctology, and in the last years, the waiting list to access UT has literally exploded to reach more than 3 000 waiting patients and an average waiting time of 3 years which justified the development of a PPT that might, if not reduce the average waiting time, help managers deciding on the relative urgency of the patients and the transparency and homogeneity of patients' evaluation towards their prioritization.

This paper is structured as follows; the next section presents a brief literature review on PPT followed by a concise description of the development of the proposed PPT for managing the prioritization of access to UT. Then, the process designed to validate the PPT is presented, and its application and results are discussed. Conclusions, further research avenues, and limitations of this work conclude the paper.

2. A brief literature review on patient's prioritization tools

Hospitals and medical centers are implementing accurate, efficient, and practical tools to accelerate the decision-making process. These tools rely heavily on optimization, forecasting models, and other innovative techniques (Salehipour & Sepehri, 2012) and (Fitzgerald et al., 2011). Among them, PPT's have received extensive attention from research because of their potential to improve the fairness, the transparence, the homogeneity, and the efficiency of the decisions related to waiting list and access to healthcare services. In a shell, PPT are designed to help managers sorting patients to decide which patients should be seen first when demand is greater than the available capacity.

In general, prioritization tools are based on a weighted set of criteria, and each patient in the waiting list is assessed with respect to each of the set’s criterion. The sum of all the values produces a score to each patient, so patients in the list are sorted according to their score. Although the set of criteria to use depends on the considered context, they tend to include personal factors (i.e., age), social factors (i.e., ability to work), clinical factors (i.e., patients’ quality of life), and possibly other factors deemed relevant by the context’ stakeholders . Furthermore, this strong dependency with respect to the context explains, according to several research, a lack of consistency in the way they are developed. For instance, (Escobar et al.,

2007) developed a prioritization tool for primary hip and knee replacement. Seven variables, pain on motion, walking functional limitations, abnormal findings on physical examination, pain at rest, other functional limitations, social role, and other pathologies according to RAND Corporation and the University of California at Los Angeles. Later, (Escobar et al., 2009) validated another patient prioritization tool, the Western Ontario and McMasters Universities Arthritis Index (WOMAC) specific questionnaire. This tool gives a score from 0 to 100 points, and separate patients into three categories: urgent, preferent, and ordinary. (Conner-Spady et al., 2004), also using (WOMAC) concluded that priority scoring systems are one way of addressing the equitable allocation of resources and, according to the authors, the main arguments in favor of priority scoring systems are transparency, explicitness, treatment in order of clinical need, and fairness.

(Pérez et al., 2018) proposed a simple and homogeneous clinical prioritization tool, the Obesity Surgery Score (OSS), that considers simultaneously and equitably the time on a surgical waiting list and the obesity severity. The obesity severity is estimated using three variables: body mass index, obesity-related comorbidities, and functional limitations. According to the authors, the tool allows prioritization of patients at greater risk, improves patient prognosis, and optimizes costs and available health resources

Despite the strong dependency of prioritization tools with respect to the specific clinical context, some researchers have tried to develop generic tools that could be broadly applied. Solans-Domènech et al. (2013) developed a linear scale to elective surgery patients' prioritization. Patients are evaluated according to three major dimensions: clinical and functional impairment, expected benefit, and social role. These dimensions include eight subcriteria: disease severity, pain (or other main symptoms), rate of disease progression, difficulty in doing activities of daily life, probability and degree of improvement, being dependent with no caregiver, limitation to care for one's dependents (if that be the case), and limitations in the ability to work, study or seek for employment. According to the authors, their tool might be applicable to all the elective patients in the Catalan public healthcare system. The Italian government founded the Surgical Waiting List Info System (SWALIS) project that aims to provide valuable data to monitor waiting lists appropriately. It allows homogeneous and standardized prioritization, enhancing transparency, efficiency, and equity. It proposes a pragmatic approach towards surgical waiting lists management, useful in both clinical practice and strategic resource management (Valente et al., 2009).

Only a few studies have tried to quantify the benefits of patients' prioritization systems. (Fantini et al., n.d.) and Comas et al., 2008 proposed prioritization tools to manage waiting lists in the context of cataract surgery. In both cases computer simulation was used to compare the mean waiting times when the waiting list was managed by a "first-come, first-served" policy and by the prioritization tools proposed by the authors. Fantini et al., concluded that priority scores may be worth the effort, given the potential ability to select high priority patients and reduce their waiting time. Comas et al., 2008 claimed that the prioritization tools shortened waiting times compared with the FIFO system, with a tendency to more substantial time savings in scenarios with longer waiting times.

Therefore, prioritization systems seem to outperform other policies that handle access to services based on waiting time only. Moreover, patient prioritization could help to manage access to care in an equitable manner although additional research needs to be conducted to evaluate facilitators and barriers to the implementation of such innovations (Déry et al., 2020). Indeed, the implementation of new technologies and tools in healthcare is a challenging process. Nadarzynski et al. reported that a substantial proportion of users was hesitant to new technologies and AI applications, mainly because of concerns about the accuracy and security of these services. Furthermore, other aspects such as the reliability and the validity of the technology need to be assessed to ensure a successful implementation.

3. A PPT for managing access to urodynamic test

Decision problems in healthcare are considered complex problems. Managing the access to UT is, due to the characteristics of the test, as well as its indications and risks, is a complex multicriteria problem. A multidisciplinary team including urologists, nurses, mathematicians, and engineers was formed to address the design and implementation of a PPT (Pécora et al., 2021). Although the development of a PPT is beyond the scope of this paper, basic notions and background on its structure are necessary to understand the nature of the validation process.

Broadly speaking, the development of the tool encompasses the three steps depicted in Figure 1. In the first step (Design), experts identify and agree on the set of criteria considered as relevant to evaluate the importance of the service for the patient. Consensus methods such as Delphi or Technique for Research of Information by Animation of a Group of Experts (TRIAGE), were used to elaborate a consensual list of criteria. Then, a hybrid method called group fuzzy analytical hierarchy process (AHP) technique was used to quantify the relative importance of each criterion with respect to the others (Marathur et al., 2015). At the end of the

Design phase, a set of criteria C, as well as a vector W containing the weight w_i of each criterion $i \in C$ such that $0 < w_i < 1$ and $\sum_{i \in C} w_i = 1$.

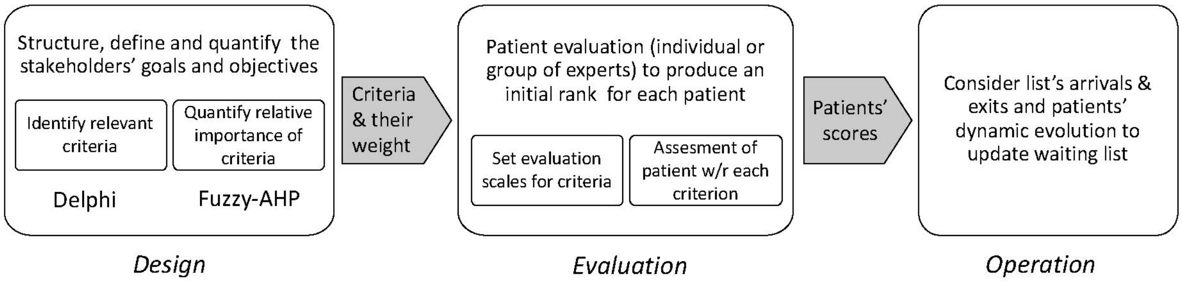

Figure 1 A general framework for PPT design and operation

The second step Evaluation seeks to assess the situation of each patient with respect to each of the criteria. To this end, an evaluation scale needs to be proposed to help assess the extent of one's situation for each criterion. Some scales are standard (for example, numerical scales for pain assessment) but in most of the cases they are proposed by the experts according to their experience and taking into account the range of values that might be observed for each criterion. Each patient in the waiting list is thus evaluated with respect to all the criteria using the provided scales by one or several experts and a global score is computed. The waiting list is sorted according to the score produced for each patient, a higher score indicating that the service has a higher value/urgency for that patient.

The third and last step, Operation, translates the sorted list into schedules for the service delivery. Indeed, practical and administrative constraints makes almost impossible to treat patients in the exact order stablished in by the patients' scores, so an optimization tool is needed to elaborate service delivery's schedules see for example (Oliveira et al., 2020). Furthermore, waiting lists are dynamic so that new patients arrive while others quit the system once they have received the required service. Finally, a patient may evolve very fast so his position in the waiting list must be re-evaluated upon a change in his situation.

4. Validation, Verification & Accreditation

Validation, Verification and Accreditation (VV&A) are important notions used in the field of Computer Simulation to establish the credibility of the models and simulations. VV&A is a process aiming to demonstrate that a computer simulation model adequately mirrors its real or conceptual counterpart and, even more important, that the results and insights extracted by experiments carried on the simulation model can be trusted as they would have been obtained from the real or conceptual artifact. We inspired from the VV&A process to achieve similar goals in the case of the development and the deployment of a computer-based PPT.

Validation of simulation models is concerned with establishing the extent to which a model is an accurate representation of the real world from the perspective of the users of the model. In our case, it concerns mainly if the choice of criteria, their structure as well as their relationships are adequate to reproduce experts' decisions. Verification is the word used to describe the process that attempts to establish that a model is adequately translated into a computer software. It involves trying to ensure that the computational model contains no errors in terms of logic and coding, including the choice of the numerical algorithms. But even if these two processes are successfully completed, the real value of any computer based-tool depends on the extent to which final users are confident with the tool and its results or recommendations are acceptable for use for a specific purpose. This final process is referred to as Accreditation or Certification and the goal is to "convince" users, who are not fully aware of the technical or engineering aspects, that the tool works appropriately.

Validation and verification, which are rather internal processes, were executed during the design and development of the PPT. This paper focuses on the accreditation of the tool which is a process involving comparisons between the model behavior and, ideally, the behavior of the real system or a golden standard for the same chosen conditions. Unfortunately, there is no golden standard to which compare the results of the proposed PPT. Therefore, we propose a more holistic, but inevitably more subjective, assessment made by someone who has a deep and thorough practical understanding of the real system. The proposed process is sketched in Figure 2.

The empirical process starts by generating a set of patients to prioritize. The choice of data sets to be used for testing models raises some interesting issues. Test data must clearly be suitable for the intended application of the model. Otherwise, it will not be possible to make decisions about the suitability and quality of the model for that application and use of the model could then be unnecessarily restricted. Then, in the absence of a golden standard, we will compare the rankings produced by the PPT to those produced by experts.

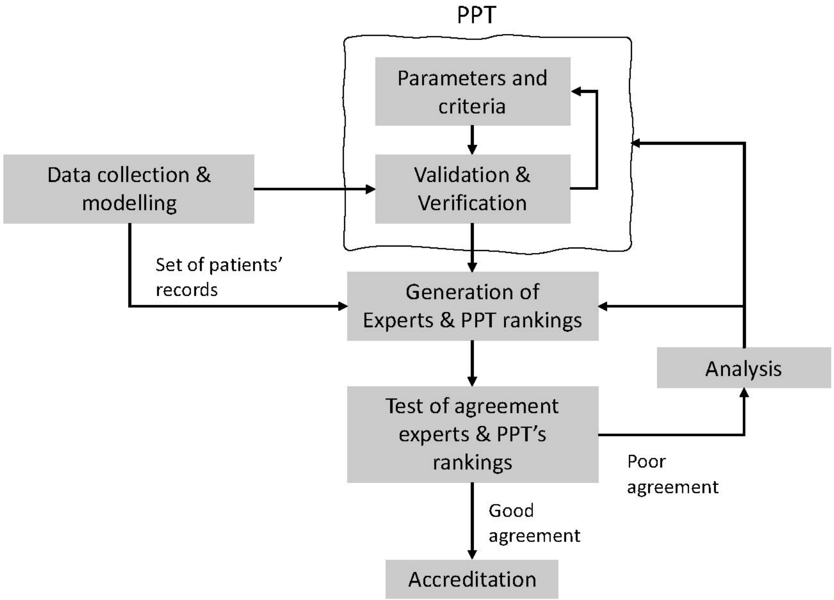

Figure 2 Process proposed for the Accreditation of the PPT

To measure the distance between any two lists or rankings σ and τ having each $|P|$ objects (patients in our case), we compute the Average Spearman footrule distance, which is defined as the sum, over all the patients $p \in P$, of the absolute differences between the ranks of p with respect to the two complete lists:

$$F(\sigma, \tau) = \frac{1}{|P|} \sum_{p \in P} |\sigma(p) - \tau(p)| \qquad (1)$$

It is worth mentioning that $F(\sigma, \tau)$, or simply F, ranges between zero (perfect agreement) and $|P|/2$ (complete disagreement). To test the agreement between the experts and the PPT's rankings we will proceed as follows:

1. We asked two experts to prioritize the set of patients independently. By doing so, we will assess the agreement between their rankings and therefore confirm the extent to which they pursuit the same goals and share the same criteria during the prioritization decisions.

2. Since the PPT requires experts to assess the condition of each patient with respect to the stablished criteria, two rankings corresponding to the evaluations performed for each expert were generated. The ranking produced by the PPT using the assessments of the first expert will be compared to the ranking produced by the first expert to evaluate their agreement. We will proceed in the same manner with the two rankings related to expert 2. Finally, the two rankings produced by the PPT will be compared to assess the robustness of the tool.

3. If the agreement is considered as high, then the Accreditation procedure is stopped. Otherwise, discussions with the experts are required to identify the reasons of discrepancies and, eventually, the PPT parameters should be adjusted.

This subjective approach can be beneficial in convincing final users of the tool correctness, but also in establishing whether the logic within the conceptual model is correct and whether the input-output relationships for the model appear reasonable. In other words, the accreditation process that we propose contributes to confirm the previous Validation and Verification decisions.

5. Applying the VV&A process to the PPT

Data collection for testing. The process began with the selection, by a nurse of the outpatient clinic of urinary dysfunction, of ten patients who had been referred for the urodynamic examination. The sample was small enough so that the doctors could sort the histories manually but at the same time it adequately represents the diversity of the patients' situations with respect to pathologies, signs, and symptoms.

Two sources of data were used. First, data already existing in the clinical records: date of the first consultation, socio-economical characteristics, results of medical exams, among others. Second, patients answered a questionnaire based on the uro-functional classification (see the Annexe). The data gathering took three weeks because the researcher allowed patients to tell their stories in detail.

A researcher transcribed the collected data into a paragraph with the patient's history format, informing the medical doctor data such as name (fictional), age, gender, work activity, test results, diseases found, among others but belonging to the uro-functional classification. This description was deemed closer to the physician reality and easier to be evaluated by them. It would be as if the doctor was reading the patient's record. An example of such a record is:

> *Female patient, 25 years old, neurogenic bladder due to congenital spinal cord injury, reports having a great loss in work activity due to the disease, has no dependents, lives with her mother. The patient retired due to disability. She reports a large amount of urine loss all the time. She waits in line for 14 months to perform Urodynamics. No renal disease, normal USG, creatinine of 0.3, and oxybutynin with significant improvement of symptoms. ICIQ = 21.*

Test of agreement – Round one. The ten patients' files (P01 to P10) were submitted to two experts who individually sorted them. One of the experts, referred to as C, was the urodynamic doctor's chief, and the other, referred to as R, was a resident urologist. Both experts had participated to the Design steps, contributing to the identification of the relevant criteria and the quantification of their relative importance.

Each expert received a copy of the ten histories and sorted them from the most to the least urgent. Experts were not allowed to talk or discuss during the evaluation. Furthermore, the patients' records were left on the table randomly, so experts were not influenced by the order in which the histories were presented to them.

Experts were then asked to assess each patient with respect to the criteria and the scales in the PPT. The PPT generated for each patient two scores, one according to the evaluations provided by the urodynamic doctor's chief and the other by the resident urologist. The scores were used to sort the patients so that the one having the highest score was considered the most urgent. The results produced by this first prioritization round are reported by Table 1 which indicates the order in which patients P01 to P10 should access the UT according to the two experts C and R, and to the assessment they provided to the PPT, PPT_C and PPT_R, respectively.

Table 1 Rankings produced by the first prioritization round

	Patients									
	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10
C	3	6	10	2	5	7	1	4	8	9
PPT_C	10	5	7	6	8	2	1	9	4	3
R	4	5	10	2	7	9	1	3	8	6
PPT_R	6	4	9	7	10	3	1	8	5	2

We compared the ordered lists or rankings produced by each expert individually and then to the ones produced by the PPT using their assessments reports the distance F between the four rankings. which in our case with $|P| = 10$ makes $0 \leq F \leq 5$.

Table 2 Average Spearman Distances (F) between the rankings produced in the first round

		τ		
$F(\sigma, \tau)$		PPT_C	R	PPT_R
	C	3.8	1.0	
σ	R			3.0
	PPT_C			1.4

We compared the ordered lists or rankings produced by each expert individually and then to the ones produced by the PPT using their assessments reports the distance F between the four rankings. which in our case with $|P| = 10$ makes $0 \leq F \leq 5$.

Table 2 shows that the rankings produced by both experts are similar, with a rank distance of $F(C, R) = 1.0$. Both experts work together at the same service, but there is slight difference in their interpretation of the facts in the patients' histories so that a perfect match is not reached. It seems that, in practice, it is improbable that two experts produce two perfect matching rankings. For this reason, we will assume $F = 1.0$ as a high agreement rate, and we will use this value as baseline for comparison.

The two rankings produced by the PPT show a good agreement, with a distance $F(PPT_C, PPT_R) = 1.4$ slightly larger than our baseline. However, when we compare the rankings produced by experts C and R to the ones produced by the PPT based on their assessments (PPT_C and PPT_R respectively) we conclude that they are pretty different. Indeed, the distances $F(C, PPT_C)$ and $F(R, PPT_R)$ rise to 3.8 and 3.0, respectively.

In conclusion, there is a very good agreement between the two rankings produced by the experts, but they are quite different of the ones produced by the PPT. Since the two rankings produced by the PPT seem pretty similar, additional research is required to identify the reason for such differences to correct the PPT if needed.

Analysis. The two experts (the chief and the resident) participated in a meeting with the researchers to discuss how they assessed and prioritized the patients in the test-set and to identify the reasons explaining the differences between their prioritization lists and the ones produced by the PPT.

We started by looking at the patients whose rank presented the largest differences between the manual and PPT's lists. By doing so, the experts realized that patients with neurogenic bladder received less priority in the manual than in the PPT rankings. Neurogenic bladder is considered the primary condition for the development of some kidney problem, and experts agreed on the high importance that it should receive in the prioritization process. Experts realized that they neglected this aspect (creatinine) that, on the contrary, received a reasonable weight during the evaluation carried out by the PPT.

Considering this fact, the researcher asked the experts to discuss and use whichever methodology they seem fit to reclassify the patients and get a new ranking.

Test of agreement – Round two. When required to sort the patients again, experts proposed a two-step approach which consisted in separating patients into three categories corresponding to high, medium, and low priority, and then sort the patients within each category. In their approach, patients with neurogenic bladder become high priority patients; patients with Benign Prostatic Hyperplasia (BPH) constitute the medium priority category, and patients with urinary incontinence refractory (UIR) and other conditions are placed in the low priority group. Furthermore, patients within each category were sorted according to their risk for developing kidney disease.

The experts resorted the set of patients' histories, prioritizing first the patients' kidney function parameters (creatinine). By reclassifying the records in this way, they concluded that, when the renal complication is similar between two patients, the disease found becomes the second evaluation criterion to determine which patient will be prioritized. In this case, the comparison discussed during the meeting was between a patient with BPH and another patient with neurogenic bladder, both with similar renal function. The patient with a neurogenic bladder will prioritize the examination due to the higher risk of the sudden development of a renal complication.

Table 3 shows a second ranking produced by the experts together (referred to as E) and reports the value of its distance with respect to PPT_C and PPT_R, the rankings produced by the PPT according to the Resident and the Chief's assessments. By looking at the values of F, we can conclude that the ranking E is closer to PPT_C, confirming that the Resident's assessments are probably less accurate. However, the values of F still demonstrate low agreement between the rankings, and therefore we decided to run a new round of discussions to try and find the cause of such differences.

Table 3 Rankings produced by the second round

	Patients										
	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	F
E	10	5	7	3	4	9	1	8	6	2	
PPT_R	6	4	9	7	10	3	1	8	5	2	2.4
PPT_C	10	5	7	6	8	2	1	9	4	3	1.8

Test of agreement – Round three. A new look at the experts' ranking E showed that patient P06 was the main "reason" for the discrepancy with the ranking PPT_C. We thus analyzed patient's P06 history in more detail and we discovered that P06 had been classified as having kidney disease, although the actual patient's condition, renal cyst grade I, was not of clinical relevance. This can be considered an "error" or inaccuracy of the data. We corrected the assessment of P06 with respect to this criterion in the PPT and a new ranking, referred to as PPT_C^* and showed in Table 4 was produced by the PPT.

Table 4 Rankings produced after correction of P06's data

	Patients									
	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10
E	10	5	7	3	4	9	1	8	6	2
PPT_C^*	9	4	6	5	7	10	1	8	3	2

Table 4 shows how the ranking produced by the PPT converges to the one produced by the experts. On the quantitative side, the value of F dropped to only 1.2 confirming again a very good agreement between the considered rankings.

It is also worth noting that P01, a patient with neurogenic bladder, was poorly prioritized by the experts and the PPT. This patient has all tests normal but needs follow-up every year to prevent kidney damage because of spinal disease. Therefore, the physicians decided that this patient should be on a separate list for periodic exams. Again, this patient is an outlier and we decided to adjust P01's priority manually to the lowest in the PPT. The final rankings, which are listed in Table 5, have a distance of $F = 1.0$, our baseline. Even more important, both experts found the ranking PPT_C^* as good and reasonable as E and both qualified the PPT as trustable, confirming that they would accept to work with rankings produced by the computer tool.

Table 5 Final rankings

Patients	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10
E	10	5	7	3	4	9	1	8	6	2
PPT_C^*	10	4	6	5	7	9	1	8	3	2

Final Analysis. Analysis of the initial difference between the reference classification and the manual classification led experts to the conclusion that they did not give Neurogenic bladder the importance that it should receive in the prioritization process. Indeed, experts were well aware of the importance of this condition, which was pointed out as highly important during the PPT"s design, but keeping in mind all the relevant criteria for all the patients during the decision making process is very challenging or simply impossible. The experts adapted their process to ensure that Neurogenic bladder was adequately considered in the assessment process and produced a second ranking whose distance with respect to the PPT's one was reduced to 1.7. Finally, analysis of the discrepancy between the two rankings lead to the identification of an error in the information related to patient P06, misleading the PTT's score. Once this information was corrected, the distance between the manual and PPT's rankings decreased to 1.0, considered as a very good agreement.

The study also pointed out utility of separating patients in clusters. By doing so, the PPT produces a very accurate classification of patients into high and low priority. Moreover, patients classified as medium priority presented very similar scores so in practice, there should wait similar times.

The validation, verification and accreditation process has helped to better understand the challenges and difficulties related to the experts' evaluation process. Invited to analyze and compare the rankings they produced to the PPT's one, experts must reconsider the relative importance they grant to each criterion, and even their relevance. During the process, experts also discovered that there might be differences between the importance they believe a criterion should receive and the actual importance the criterion receive in their decisions. The two experts acknowledged that stability in the application of criteria importance is a key feature of PTT. Finally, the two experts agreed to express a strong confidence in the results produced by the tool and therefore their recommendation for a practical implementation.

- ## Conclusion

This paper proposes and discusses a Validation, Verification and Accreditation (VV&A) framework to assess the extent to which a Computer-based Patient prioritization tool (PPT) conceived to manage patients' access to the urodynamic test in the urology service at the Hospital de Clínicas of the Federal University of Parana, Brazil, can produce outcomes that satisfying experts' requirements prior to its potential implementation. The VV&A aims to identify and explain differences between the prioritization decisions made by experts and those made by the PPT, the final goal being to assess the extent to which PPT's decisions should be trusted. To this end, a series of recursive test were executed where a set of patients needed to be ranked according to their priority and the disagreement, measured as the Average Spearman footrule distance was computed. We observed first a high agreement between the decisions of the two experts who showed a strong disagreement with the PPT. After analyzing the results, experts realized that in their evaluations they did not give to one of the criterion the importance it should receive. Once they reevaluated the patients, the disagreement with respect to the ranking produced by the PPT decreased strongly. Further investigation discovered a mistake in the information related to one of the patients to rank. Once it was correct, the distance between the manual and PPT's rankings decreased to 1.0, considered as a very good agreement, confirming the good performance of the tool. To summarize, the VV&A tests proved to the experts the value of the proposed PPT to adapt, restructure, clarify, and correct any errors or misinterpretations between the tool and the experts in prioritization decisions.

Nonetheless, the VV&A process carried out have some limitations. Firstly, the set of 10 patients used for the tests does not cover any potential profile nor any clinical situation. Larger samples of patients need to be considered to confirm the behavior of the tool before a practical implementation. Also, the description of the patients in the test set encompasses data extracted from two sources - clinical records and a questionnaire filled by patients - and it was "*transcribed*" by a nurse into historical-like records which tends to homogenize the actual information presented to the experts. Consequently, additional tests should be run with real patients to ensure that no bias was introduced during the production of the test-patients. A second limitation concerns the potential discrepancy among experts' opinions. The experiments were conducted with two experts who work together at the same service. Even though, their rankings reach a distance of $F(C, R) = 1.0$. It is possible that two other experts might produce rankings with larger discrepancies. Since the design of the PPT "averages" the experts' opinions, it might also be possible that an expert rejects other rankings, including the one produced by the PPT. Internal communication is a key factor in technology implementation and special attention must be given to adequately explain that the rankings produced by the PPT will resemble those produced by the experts, but they will probably be different from each of them individually. Finally, communication must enlighten the benefits of homogeneous criteria and evaluation as a mean to achieve fair access to health services.

• Acknoledgements

This study was funded by the program Recherche en Équipe of Fonds de recherche du Québec Nature et Technologie.

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Appendix 1

- URO-FUNCIONAL QUESTIONNAIRE – I

NAME: ______________________________ ID:_______________

DESEASE FUNDED

Neurogenic Bladder / neurological disease ( ) yes ( ) no

BPH – IPSS > 20 scale:

UI ( ) yes ( ) no

BH

UUT

IUE

SOCIAL

Age ___

Waiting times ____ months

Dependents ___

Work activity impairment:

Low

Medium

High

Nothing

Health Problems

Kidney problems:

Signs of renal failure:

Edema of lower limbs;

Low urine volume <500ml - on a daily basis;

History of uremia

infection in the kidney

Pyelonephritis

Recurrent bladder infection or clotted urine

Recurrent low UTI or pyuria

Pelvic Organ Prolapse I/ II/ III/ IV

Weak urine or long delay in achieving urination

Weak urine stream or prolonged urination

Weak urine stream or prolonged urination

Needs catheter (Patient in urinary retention)

Incomplete emptying

Go to the bathroom several times OR 1 time or more every 1 hour (Polyuria)

Single kidney

Kidney transplant

Quality of Life - ICIQ

How often do you lose urine

Never (0)

Once a week or less (1)

Two or three times a week (2)

Once a day (3)

Several times a day (4)

All the time (5)

The amount you think you lose urine is:

None - 0 pt
Small amount - 2pt
Moderate amount - 4 pt
Large amount - 6 pt
How much does losing urine interfere with your life? Please choose a number between 0 (does not interfere) and 10 (interferes a lot)
0 1 2 3 4 5 6 7 8 9 10

- Total points part I __

Complementary exams
Ultrasonography
Reduced renal cortical thickness
Normal
Not done
Cortical scars/ retractions
Pyelocaliceal dilatation
Accentuated
Moderate
Slight
Absent
Stress bladder (thickened - >5mm; trabeculations)

Renal function (calculation with CKD-EPI)
Creatinine > 2

7 CONSIDERAÇÕES FINAIS

Com esta pesquisa concluímos que a metodologia de gestão de projetos, baseada nos passos desenvolvidos pela escola de administração da Universidade de Harvard, foi de grande valia para construção do grupo multidisciplinar, para elaboração dos critérios de prioridade do estudo urodinâmico e para escolha do método de análise do estudo. O comprometimento de toda equipe multidisciplinar foi fundamental para o sucesso do estudo.

O método Fuzzy AHP, foi bem escolhido para a determinação dos pesos para os critérios de prioridade, por ser um método de decisão baseado em multicritérios, o qual o estudo uridinâmico está incluído. Além disso o Fuzzy AHP tem sido utilizado em diversos países para determinação de scores de prioridade na área da saúde.

A validação e verificação do PPT, através do processo de simulação, tendo como base uma situação real, com dados de pacientes reais, foi imprescindível para determinação correta dos scores de prioridade do estudo urodinâmico. Este processo trouxe aos experts uma nova forma de avaliar os pacientes, um novo olhar para tecnologia e a importância da integração com diferentes áreas tecnológicas.

Com esta validação desta ferramenta de priorização, podemos concluir que a mesma está apta para ser implementada. Com isto poderemos ajudar o gestor na tomada de decisões e melhor controle da fila de uma forma mais justa. A ferramenta proporciona mais transparência, agilidade no tratamento e minimiza os riscos de agravos a saúde dos pacientes, consequentemente estas ações diminuirão os custos com cada atendimento.

7.1 RECOMENDAÇÕES PARA TRABALHOS FUTUROS

Com o retorno das atividades hospitalares eletivas, após a pandemia de Covid19, já podemos começar um novo estudo para implementação deste método e utilização da plataforma de priorização.

Após a implementação da ferramenta novos estudos de avaliação e controle poderão ser realizados, visando cada vez mais aprimorar a ferramenta.

Outros estudos com qualquer problema multicritério, como filas cirúrgicas, exames, consultas, poderá ser realizado através desta ferramenta de inovação.

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ANEXO A – QUESTIONÁRIO UROFUNCIONAL

- NOME: ________________________________ RG:________________
- Doença Encontrada
  - Bexiga Neurogênica / doença neurológica ( ) sim ( ) não
  - HPB – IPSS > 20 escalas:
  - IU refratárias ( ) sim ( ) não
  - BH
  - IUM
  - IUE
- SOCIAL
  - Idade ___
  - Esperando exame há ____ meses
  - Número de dependentes ___
  - Prejuízo a atividade laboral:
  - Baixo
  - Médio
  - Alto
  - Nada
- AGRAVOS
  - Problema nos rins:
  - Sinais de Insuficiência Renal ( ) sim. ( ) não
  - edema de membros inferiores;
  - baixo volume urinado <500ml – em diário;
  - história uremia
  - Infecção no RIM:

- Pielonefrite
- Infecção de repetição na bexiga ou urina com grumo
- ITU baixa recorrente ou piúria
- Prolapso de Órgão Pélvico I/ II/ III/ IV
- Urina fraca ou demora muito para conseguir urinar
- Jato fraco ou micção prolongada;
- Urina trava
- precisa de sonda (Paciente em retenção urinária)
- Esvaziamento incompleto;
- Vai várias vezes ao banheiro OU 1 vez ou mais a cada 1 hora (Polaciúria) –
- RIM ÚNICO
- Transplante renal

- QV - ICIQ
  - Com que frequência você perde urina
    - Nunca 0
    - Uma vez por semana ou menos 1
    - Duas ou três vezes por semana 2
    - Uma vez ao dia 3
    - Diversas vezes ao dia 4
    - O tempo todo 5
  - A quantidade que você pensa que perde urina é:
    - Nenhuma – 0 pt
    - Pequena quantidade – 2pt
    - Moderada quantidade – 4 pt
    - Grande quantidade – 6 pt

- O quanto perder urina interfere em sua vida? Por favor escolha um número entre 0 (não interfere) e 10 (interfere muito)
  - 0 1 2 3 4 5 6 7 8 9 10
- Total pontos parte I XXXX pts TOTAL: ________ PT

ANEXO B – TCLE TERMO DE CONSCENTIMENTO LIVRE E ESCLARECIDO PACIENTE

O (a) senhor (a) ___________________________ está sendo convidado a participar da pesquisa Projeto de Priorização da Fila de Urodinâmica no qual eu, Ana Tereza L. Pécora, sou pesquisador. Essa pesquisa quer melhorar a realização de exames na Urologia do Hospital de Clínicas da Universidade Federal do Paraná. Nenhuma informação será divulgada em seu nome e que o sigilo total de seus dados será mantido. Não haverá gastos ou benefícios imediatos para o(a) senhor(a), entretanto a informação será de grande valor para a pesquisa.

ANEXO C – TCLE TERMO DE CONSCENTIMENTO LIVRE E ESCLARECIDO MÉDICOS

O (a) senhor (a) ___________________________ está sendo convidado a participar da pesquisa Projeto de Priorização da Fila de Urodinâmica no qual eu, Ana Tereza L. Pécora, sou pesquisador. Essa pesquisa quer melhorar a realização de exames na Urologia do Hospital de Clínicas da Universidade Federal do Paraná. Nenhuma informação será divulgada em seu nome e que o sigilo total de seus dados será mantido. Não haverá gastos ou benefícios imediatos para o(a) senhor(a), entretanto a informação será de grande valor para a pesquisa.